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An Illustrated Weekly Journal.

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COUNTY BOROUGH OF SOUTHAMPTON.

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The Corporation invite

Tenders for the Supply,

DELIVERY and ERECTION at their Electricity Works, Western Esplanade, of the following PLANT:—

(A) Two Water-tube Boilers, complete with Superheaters, chain grate-stokers, economisers, mountings, etc.

(B) One Set of Induced-draft Fans and Steel chimney, etc.

(C) Steam, Feed-water, and other Piping, Covering, etc.

Specifications may be obtained from the Borough Electrical Engineer at the Electricity Works, Western Esplanade, Southampton, upon production of the Borough Treasurer's receipt for a deposit of £2 2s. Deposits will be returned after the Council have dealt with the Tenders, to Contractors who have submitted *bona fide* Tenders. Additional copies of the Specifications may be obtained upon payment (not returnable) of £1 1s. per copy.

Sealed Tenders, endorsed "Boiler House Plant," must be delivered at the Town Clerk's Office by Twelve o'clock at Noon on Tuesday, the 26th August, 1924.

No pledge is given to accept the lowest or any Tender.

R. R. LINTHORNE,
Town Clerk.

18th July, 1924. F 399

The Director-General,

India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

1. WHEELS and AXLES.
2. MILD STEEL SLUICE GATES, 60 ft. by 16 ft., with gear.

Tenders due on the 6th August, 1924, for No. 1, and on the 15th August, 1924, for No. 2.

Tender forms obtainable from above. F 420

THE BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for:—

WROUGHT IRON, STEEL AND OTHER FITTINGS FOR CABOOSE BRAKE VANS.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 21st July, 1924.

A fee of 20s. will be charged for the Specification, which is NOT returnable.

Tenders must be submitted not later than Noon on Thursday, 7th August, 1924.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By Order of the Board,
R. C. VOLKERS,
Secretary. F 403

TYNE IMPROVEMENT COMMISSION.

TEN-TON OVERHEAD ELECTRIC TRAVELLING CRANE AT HOWDON YARD.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Delivery and

ERECTION of a Ten-ton OVERHEAD ELECTRIC TRAVELLING CRANE at their NEW ERECTING SHOP at HOWDON-on-TYNE.

Specification and General Conditions of Contract may be inspected at the Offices of the Architects, Messrs. CACKETT & BURNS DICK, FF.R.I.B.A., Pilgrim House, Pilgrim Street, Newcastle-upon-Tyne, and manufacturers desirous of Tendering for the work should forward their names and addresses to them not later than 5th August, 1924, together with a deposit of £2 2s., which amount will be returned upon receipt of a *bona fide* Tender.

Tenders in sealed envelopes, endorsed on the cover "Tender for Overhead Electric Travelling Crane," must be addressed to the Chairman, Dredging and River Works Committee, and delivered at the undermentioned Offices not later than Noon on 15th August, 1924.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK, Secretary.

Tyne Improvement Commission Offices,
Bewick Street,
Newcastle-upon-Tyne.
21st July, 1924. F 422

TYNE IMPROVEMENT COMMISSION.

TWIN SCREW STEAM FERRYBOAT.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Construction

and DELIVERY in the Tyne of a TWIN SCREW STEAM FERRYBOAT.

Copies of the Form of Tender, Conditions of Contract, Specification and outline Drawings may be obtained on application to the undersigned on payment of a deposit of £2 2s. which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes endorsed "Tender for a Twin Screw Steam Ferryboat," must be delivered at the undermentioned offices addressed "The Chairman, Harbour & Ferry Committee" not later than Noon on Monday, the 18th day of August, 1924.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
ALBERT BLACKLOCK,
Secretary.

Tyne Improvement Commission,
Bewick Street,
Newcastle-upon-Tyne.
18th July, 1924. F 331

GREAT NORTHERN RAILWAY (IRELAND).

TO BRIDGE CONTRACTORS.

The Directors are prepared to receive

Tenders for the Reconstruction

of a STEEL UNDERLINE BRIDGE, between Newbliss and Clones.

The Drawings and Specification may be inspected at the Engineer's Offices, Dublin and Belfast, and copies of same, together with Bills of Quantities and Forms of Tender may be obtained from the Undersigned on payment of Two Guineas, which will be refunded on receipt of a *bona fide* Tender, and on return of the Drawings.

Tenders, made out on the Forms supplied by the Company, should be delivered under sealed cover endorsed "TENDER FOR BRIDGE," not later than Ten a.m. on Monday, 18th August, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

J. B. STEPHENS,
Secretary.

Amiens Street Station,
Dublin, 22nd July, 1924. F 424

THE SOUTH INDIAN RAILWAY COMPANY LIMITED, are prepared to receive

Tenders for the Supply of:—

STEAM TRAVELLING CRANES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked, "Tender for Steam Travelling Cranes," must be left with the undersigned, not later than Twelve Noon on Friday, the 22nd August, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of the Specification.

Copies of the Drawings may be obtained at the Offices of the Consulting Engineers to the Company, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
23rd July, 1924. F 443

APPOINTMENTS OPEN.

UNIVERSITY COLLEGE OF SWANSEA.

Applications are Invited for

the POST of LECTURER in CIVIL ENGINEERING. Salary £500 per annum. The appointment will date from October 1st, 1924.

Further particulars may be obtained from the undersigned, by whom applications must be received on or before August 23rd, 1924.

EDWIN DREW, Registrar.

Singleton Park, Swansea. F 409

UNIVERSITY OF DURHAM
Armstrong College,
Newcastle-upon-Tyne.

LECTURESHIP IN ELECTRICAL ENGINEERING.

The Council of Armstrong College invites

Applications for a Lecture-

SHIP as above. Grade A, £600 or Grade B, £400-£500, according to qualifications. Appointment to date from October 1st, 1924. Ten copies of applications and of not more three testimonials to be received not later than July 31 by the undersigned.

J. Y. T. GREIG,
Registrar,
Armstrong College,
Newcastle-upon-Tyne. F 347

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PRINCIPAL: H. Schofield, M.B.E., Ph.D. (Lond.), B.Sc.Hons. (Lond.), A.R.C.Sc. (Lond.), Assoc. M.Inst.C.E., M.I.Mech.E., D.I.C., F.Inst.P.

DEPARTMENT OF MECHANICAL AND CIVIL ENGINEERING.

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Applicants must have had considerable Works and Teaching experience and be capable of preparing students for the Honours (Engineering) Degree of the University of London.

Burnham scale of salary (with agreed reductions).

Forms of application and further particulars may be obtained from the REGISTRAR, to whom applications must be sent by the 2nd August, 1924.

W. BIRRELL,
Registrar. F 378

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Principal: C. L. ECLAIR-HEATH, Wh.Sc., A.M.I.M.E.

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Education Office, Northumberland Road. F 416

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REQUIRES ELECTRICIANS, ELECTRICAL FITTERS, ENGINE-DRIVER FITTERS and WIRELESS OPERATORS. Age limits 18 to 30. Pay from 34/6d. to 38/6d. per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call, INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. F 916

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Africa, Diesel DRIVER, single man, with Power station experience preferred.—Write, stating experience to B. 511, care JACKSONS, 19, Cullum Street, E.C.3. F 902

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WANTED, for Cotton Ginning Factories in British East Africa several YOUNG ENGINEERS, ages about 24 to 28 years. Must possess good all-round knowledge of General Engineering and be familiar with Gas-Producer and Steam Engines; able to carry out general overhauls and repairs without supervision, assisted by unskilled native labour. Three years' engagement, free quarters, passages paid out and home.—Write, stating in first instance, full particulars of experience and where gained, age and wages expected to "P.G." c/o J. W. VICKERS & Co., LTD., 5, Nicholas Lane, E.C. 4. F 419

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Argentine Railway, 2 JUNIOR ASSISTANT QUANTITY SURVEYORS, age 22/24. Must have had not less than four years' experience with firm of quantity surveyors, architects or builders and be thoroughly versed in building construction, quick at figures and good writers. Salary £300 to £360 according to age and experience, with further £70 if examination in Spanish passed after twelve months.—Write, stating particulars, education training, experience, age, with copies (only) testimonials, to BOX K.L., c/o DAVIES & Co., 95, Bishopsgate, E.C.2. F 420

Electrical Engineer Wanted

by large industrial company. First-class technical training and experience in generation, transmission and use of A.C. and D.C. electric power essential.—Address, by letter, stating age, and giving full particulars of training and experience to F 415, Offices of ENGINEERING. Original testimonials should not be sent.

Salesman, with Good Connec-

TIONS in steam, boiler and power plant users, REQUIRED in a London firm for working U.K.—Address particulars, stating age, qualifications for position and salary required, F 417, Offices of ENGINEERING.

Wanted, Chief Engineer and

DRAUGHTSMAN for old-established Gas and Chemical Engineers in North of England. Must be good practical as well as theoretical Engineer. Permanent position for good man. State age, salary and full particulars.—Address, F 286, Offices of ENGINEERING.

Draughtsman Wanted for

Liverpool, knowledge of compressor design essential.—Address, F 283, Offices of ENGINEERING.

Junior Draughtsman Wanted,

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with experience in making of suitable drawings for reproduction REQUIRED by Engineering firm thirty miles north of London.—Address, stating age, experience and salary required, F 397, Offices of ENGINEERING.

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WORK DRAUGHTSMAN, thoroughly experienced in designing for and preparing fully detailed shop drawings for Steel Bridge and Roof Work. State age, details of experience, and salary required.—Apply, FRANCIS MORTON & CO., LTD., Engineers and Contractors, Hamilton Ironworks Garston, Liverpool. F 402

CITY OF BIRMINGHAM WATER DEPARTMENT.

Draughtsman Required

TEMPORARILY for work in connection with Reservoir with Earthen Embankment.

Must be thoroughly experienced in design of Waterworks, Pipe-lines, Valve Houses, Reinforced Concrete, etc.

Salary—Seven Guineas per week.

To reside at Ludlow.

Applications, endorsed "Draughtsman," stating age, experience, etc., with copies of two recent testimonials, should be sent to the SECRETARY, Water Department, Council House, Birmingham, on or before 30th July, 1924. F 363

PROCEEDINGS OF THE FIRST WORLD POWER CONFERENCE.—IV.

WE now conclude our report of the proceedings of the World Power Conference, the final meeting of which was held on the 11th instant. As before, we publish abstracts of a few selected papers and deal with the remainder in our general account of the proceedings. The Conference brought together such a large collection of valuable contributions that we have not as yet been able to deal with all that we wish to notice, and a selection of some of these will be given in latter issues.

SECTION N. RESEARCH.

This section dealing with Research met in the afternoon of the 8th instant. A report by the Austrian Laboratories for Technical Research and Testing Materials was submitted, on the various institutions in Austria for scientific and experimental research. In addition to some 230 public research or testing laboratories in Germany and 80 in Austria, there are probably an even greater number of industrial laboratories attached to individual works. The technical high schools form the centre of scientific work, and cover the Graz laboratories for elementary mechanics and for mechanical testing, conducted respectively by Professor Heyn and Professor Leon, in addition to a Mining University at Leoben. The Technical High School at Vienna has a number of special laboratories, including the Institute for Gravitation, conducted by Professor Schumann, the Laboratory for Testing Fuels and Gas Lighting, conducted by Professor Strache, Professor Paweck's Electro-Chemical Laboratory, the Electro-Technical Institute, Professor Ludwik's Laboratory for Testing Materials, and Professor Urbanek's Aero-Mechanical, Hydro-Mechanical, and Tools and Machine Tools Laboratories. In addition to these laboratories, which are devoted partly to scientific research, partly to testing, and partly to teaching technology, some of the technical schools also have laboratories, and Government departments have created institutes for purposes such as experimenting on hydraulics and river engineering and geological research. In addition, there are a number of private bureaux, created and maintained by associations and societies, including laboratories for testing models of ships for resistance, motor-cars, heat economy, and radium.

Dr. A. F. Enström (Sweden) read a paper on the Organisation of Research Work in Sweden. Such work dated back to the beginning of the eighteenth century, and during the nineteenth century special colleges were founded for subjects such as agriculture and forestry, in which necessary research work was carried out under the direction of the professors. At the end of the century a special testing laboratory was started for routine testing both in agriculture and industry; the latter was reorganised in 1920, and is now working much on the lines of the British National Physical Laboratory. Special research laboratories have been instituted in Stockholm for cellulose and for metallography, and several boards were set up by the Government during the war to investigate specific problems as to raw materials, fuel resources, &c. A central institution was founded in 1919 for the purpose of co-ordinating research work, avoiding overlapping, and securing continuity. This Institute of Scientific and Industrial Research, though it was started with Government and Parliamentary support, and its by-laws and some part of its membership were approved by the Government, is expressly not a Government department. It is composed of leading technical men, eminent both in theory and practice, who retire automatically at the age of 65. Its funds are provided partly by Parliament and partly by industry. Its work is divided into seven distinct permanent boards, dealing respectively with the mechanical, electrical, building, chemical, mining and metallurgical, psychological and allied sciences. Special boards undertake investigation from time to time into specific problems, and two special research associations have been formed by the industries of peat and of shale and lime respectively. Branch research associations covering the main fields of industry are intended to be formed when trade is more satisfactory. Close co-operation is maintained with the various Government and professional bodies and the universities.

In the discussion that followed these papers Dr. Patterson (Research Laboratory, General Electric Company) expressed approval of the practice of appointing advisory boards from among technical men to keep touch with scientific investigation, believing that they exercised a moral influence in keeping the investigators in touch with the practical aspects of their work. On the other hand, he regarded provisions to prevent overlapping as directly mischievous, overlapping having a direct advantage both in developing slightly different aspects of the same problem, the differences of which might be real and suggestive, and in furnishing a useful and independent check on the work of each investigator when it had proceeded along the same lines.

Mr. Skinner (Westinghouse Research Laboratory, U.S.A.) spoke of the great influence of the National Bureaux of Standards and Mines and the National Research Council in stimulating research even more than in carrying it out. His own company, like the General Electric and Western Companies, carried out investigations in pure science as well as in the direct attack on specific practical problems. Those responsible for such work did not always find it easy to get the necessary grants, but more than once in his own experience the executive side of his company had realised the ultimate practical advantage of such purely theoretical enquiry. Some time ago, for example, he had considerable difficulty in getting the necessary appropriation for organising a section in the laboratory for studying the production and maintenance of vacua, with the special object of collecting a staff that could tackle problems of modern molecular physics. It happened, however, that occasion arose in the works for some new means of attaining a particular result, which their research laboratory was able to devise rapidly, and he found no further trouble in getting what grants he wanted. Mr. George Westinghouse himself, though alive to the value of experiment, was impatient of experiment on a laboratory scale, and often insisted on it being made at once on the full works scale, so that if successful the results could be applied immediately in practice. A more usual way was to separate the investigation of a new design into the three stages of proving, testing, and developing it on a full-size scale. Sometimes, however, the more direct method might be used with advantage. Having on one occasion to seek the solution of an important metallurgical problem, he had to work for two months with experiments on 30 to 50-ton lots, conducted at top speed, and smashing up the plant in the process; but they arrived at the result they wanted, and it was worth millions to the works. More could be done by co-operation in different firms were it not for the practice of working on patents, which tended to restrict co-operation between industrial laboratories to general lines.

Sir Frank Heath, of the Scientific and Industrial Research Department, doubted whether those who were organising research gained much by troubling about the mechanism used in other countries for the same purpose, as, for example, whether it should be by a central body, as in the United States, or by a sort of compromise as in Sweden. The arrangement that was best for each country would usually be determined by its own national considerations. In particular it was desirable to avoid using too much mechanism. Early in the war it was realised widely in England that no one had sufficient knowledge of how urgent problems of research should be attacked, where the men were that could attack them, and how such men could be brought into co-operation. It was natural that in these circumstances the thoughts of many should turn on mechanism, and at the outset the Research Department was pressed in many quarters to establish a great central clearing house to collect and tabulate the results of scientific research and make them generally available. The Department refused steadily to institute such a mechanism, feeling that, in addition to requiring enormous supplies of money and men, the researches would have to be filtered through persons who were not themselves workers, and their effect would run the risk of being lost or even misconceived. So far as concerned international co-operation it seemed to him that a condition precedent was for each country to organise its own research workers, and in particular to bring those who were growing up in research into contact with each other. When this had been done, it would be time to bring the men who had been so organised into contact with similar organisations of other countries. A further object was to bring industrial workers in contact with men of science, and to impress on Government officials that even for a wise administration scientific help was necessary. It was with this view that the Advisory Council of the Research Department had always committed research work into the hands of men representing the industries concerned. An essential condition of progress was a certain individual liberty to experiment, and to speculate with money, which in some instances would be lost. It did not lie with him to express the opinion that the work of the Research Department had been a success; but he was able to say, as a matter not of opinion but of fact, that it had secured support from many thousands of the foremost men in both science and industry.

Professor McNussen (Washington) urged the importance of keeping research an essential part of the work of universities and technical schools. Mr. George A. Taylor (Australia) suggested that research workers in the countries he had been visiting were not receiving adequate remuneration. Dr. Brookes (Bureau of Mines, U.S.A.) gave several instances of practical problems to the solution of which the work of the Bureau was contributing, though it had been started originally for the purpose merely of investigating questions of safety. How far such work might be of practical advantage was illustrated by what had been done recently by a team of seven men from the Bureau, who in co-operation with the United States Association of Manufacturers of Refractories, visited a number of works and secured for them reductions of fuel consumption of from 10 to 40 per cent. Apart from its contributions to the solution of specific problems, the Bureau did a large amount of routine analytical work, and in particular had made analyses of about three-fourths of all the coals mined in the United States.

Mr. O. Taussig (Austria) read a paper on Electro-Aeronautic Research Work, urging the utility of two patented electro-dynamic methods for exploring the interior of the earth with the object of discovering ore or water; and Professor Richard Schümann described some results obtained with the torsion balance or variometer, with the object of constructing lines of equal gravity and revealing subterranean faults or dislocations. In the discussion that followed Captain Shaw pointed out that Mr. L. Oertling had made and was exhibiting in H.M. Government Building a balance similar to that described by Professor Schümann; and Mr. E. Lankester Jones

stated that other methods on the same lines as described by Mr. Taussig were not subject to patent and might be practised by anybody.

SECTION H. ELECTRICITY IN AGRICULTURE.

On the morning of the 9th instant this section of the Conference met under the chairmanship of Mr. J. Bache-Wiig, Director of the Electric Bureau, Norway. Three papers were read, the first being that of Mr. R. Borlase Matthews (Great Britain) on "Electro-Farming Economics." Mr. Matthews stated that great economies were possible by using the electricity, and gave diagrams showing how even a good existing load factor for a farm could be improved by utilisation of this power. He believed that the solution of the problem of rural depopulation could be solved by means of electric power rendering rural areas suitable for localised industry. Whatever should be the system of main distribution, however, the real problem was sub-distribution. Mr. Matthews had found satisfactory extra high-tension supply, distributed after reduction to 10,000 volts at main substations, to small static sub-stations. Sub-divisions from these small sub-stations were dealt with by two main systems. Both dealt with areas having a radius of 2 miles. In the one case, according with Swedish and American practice, the 10,000-volt pressure was reduced to 2,300 volts (or possibly 1,500 volts), at which it was transmitted direct to various farms. Each farm was equipped with a three-phase 2,300-380-220-volt transformer suitable for purposes of normal lighting and small power load. In the case of heavy loading being required of a more or less temporary nature, *e.g.*, a 40-h.p. threshing motor, a portable 2,300-380-volt transformer was employed. The second method was to step down directly from 10,000 volts to 380-220 volts, and then do all the sub-distribution at this pressure. In this instance the sub-station transformers were correspondingly large, viz., from 50 kv.-a. upwards. Such transformers supplied several low-tension distributors radiating from it, each being up to 2 miles long. There was naturally rather a large voltage drop on heavy day loads, so that large motors connected to the ends of the low-tension lines were usually wound for 15 per cent. lower voltage. But much could be done to correct this poor regulation by correcting the power factor by any suitable means.

The second paper read was that entitled "Electricity in Agriculture," by Dr. H. Wallem, of Germany. In it he maintained that almost all farming machinery could advantageously be driven by electric motors. Expense forbade supplying a motor for each machine, so that a single portable motor for driving a number of machines mounted at various places was customary. Different types of motors had been developed for this purpose, which were classified into (*a*) portable motors, (*b*) direct-coupled motors, (*c*) motor sledges, (*d*) motor carts and (*e*) motor vans. Regarding portable motors, a maximum output of 3·7 h.p. without speed reduction gear or belt drive was usual, but only up to 2 h.p. when reduction gear was used. Switch, starter, and fuses were usually all mounted in a common box fitted to the motor frame. The fuses were arranged in such a manner that they could only be inserted in the circuit when the switch lever was in the "on" position in order to prevent the fuses blowing on account of the high starting current used. Connection was made to the service lines by double-braided flexible conductors in vulcanised rubber, with a standard plug and socket. Of the direct-coupled motors suitable for hand-driven farm machines, those having outputs up to 1 h.p. were used. A speed reduction gear was built into the shell of the motor, converting the high motor speed of 3,000 r.p.m. into the lower speed desired for the farm machine of 60 revolutions. The switch was also contained in the motor shell, and the motor directly coupled with the shaft of the farm machine by means of a coupling.

In Germany the Elmotor had found favour on account of its compact design, small weight, and large starting torque. Regarding motor sledges, these usually consisted mainly of two ironclad wooden runners with strong joint pieces between them on which the standard open type motor from 1·5 to 13 h.p. was mounted. A cover of wood or iron with ventilating holes was used to protect the motor and switchgear against rain and injury. Carts were used for transporting motors over larger distances, the motor, for sizes up to 13 h.p., being mounted on a two-wheel cart. Vans were used for motors of larger size, being divided into two sections, one for the motor and starter, and the other for the cable drum, or cable saddle, including fuses. For starting, a drum type starter with a primary switch was usually employed. He considered electric ploughs fairly economical, and stated that an electric rotary tiller, drawn by a 30-h.p. electric tractor, was now being developed.

The next paper to be considered was that on "Electricity in Sweden," by Nils Ekwall, Government Adviser on Agriculture. In his absence the paper was read by Mr. R. Borlase Matthews. Attention was drawn to the rapid progress of electrical development applied to farming during the last ten years in Sweden, mainly from water-power sources. Fully 40 per cent. of the total arable land was now so developed. By far the most important application of electricity in the countryside for power requirements was the running of motors. Types differed widely in the north and southern parts of the country, however. In the latter where agriculture was of the greatest importance, usually larger motors up to 30 h.p. were used, while in the Norrland smaller machines were the rule. The larger motors, mainly used for threshing, were employed by a number of adjacent farms, which then formed a threshing company. The small 1½-h.p. motors always belonged to the farm on which they were used, and in many cases were portable. The power installed amounted to 260,000 kw., according to the paper, which gave a good deal of data on Swedish conditions.

Professor R. Sibley, of California University, then gave a number of statistics relating to Californian practice; 0·650 million kw.-hours were used on 6 million acres of land. The utility companies usually shared expenses equally with the farmer towards erection costs of transmission lines. These latter extended, in all, to some 1,400 miles in the country. Power was led down from the mountains 200 miles inland from water sources. In connection with the well-known fruit industry, raisins, &c., were now packed entirely by electricity, while chicken hatching with power up to 600 watts and refrigeration with 25 h.p. were common.

SECTION J. ELECTRO-CHEMISTRY AND ELECTRO-METALLURGY.

Section J. met on Wednesday, July 9. Power in Electro-chemistry was discussed in the morning session under the presidency of Mr. H. Horn, of Kristiania.

The first paper taken, a report by Dr. Heinrich Paweck, of the new Institute for Technical Electro-chemistry at Vienna, on "the Austrian Electro-chemical Industry," regretted that definite data of the condition of the industry in the new State were not yet available, and that figures from industrial sources only were obtainable. Extension of water power and research were gradually restoring the industry. The refining plant of the Mitterberger Copper Company at Ausserfelden, produced copper, and copper and nickel sulphate, from local pyrites. Copper was also refined in the Vienna arsenal, but many refineries erected during the war had been abandoned. The three aluminium works at Lend-Gastein (a branch of the Neuhausen Company) and of Stern and Haffert at Steeg used a total of 24,000 h.p., mostly hydro-electric power. The Lend works, and also Landeck (14,300 h.p. water), and Deutsch Matrei, produced also calcium carbide; ferro-alloys were made at Treibach and Mühldorf; the chief electric steel works were those of Schoeller in Ternitz, Boehler and Co. in Kapfenberg and Blackmann in Mürzzuschlag. Of well-known importance for alkalis and chlorine were the works of the Bosnian Electric Company at Brückl, of Leykam-Josephthal Ltd. at Gratwein, and the plants of the Kellner-Partington Paper Pulp Company of Manchester. The nitrogen fixation plant at Patsch took about 12,000 h.p. (water). The precious metal and galvano-technical (Langbein-Pfanhauser and Berndorf) works, retained their reputation. In many of these plants the processes of Austrian inventors (Billiter, Paweck, Pfanhauser, K. T. Bayer, aluminium from bauxite) were being worked.

In his report on "Nitrogen Fixation," Dr. B. F. Halvorsen dealt with the Birkeland-Eyde (taking 260,000 h.p.) and the Schönherr (110,000 h.p.) processes in use in his country, Norway, and with other arc processes, with the cyanamide processes, and briefly with the synthetic ammonia processes of Haber, of Claude, of Casale, of Fauser (Spain) and of De Jahn (General Chemical Company, Sheffield, Alabama). He summed up in favour of the arc process which, though requiring more energy than others for operation, yielded much utilisable heat. Casale plants were working at Terni, Italy, and in Japan, and a plant was being erected at Niagara Falls. Dr. Halvorsen stated that Casale compressed the gases to about 600 atmospheres in well-constructed furnaces. During the discussion Mr. Diény, of Paris, mentioned that the French government worked a large war-time plant of the Haber type near Toulouse, using water power from the Pyrenees. The Claude plant at Béthune was nearly completed, and many collieries in the North of France were working Claude or Casale plants with coke-oven gas. Claude recommended his process chiefly for the local production of ammonium sulphate on a small scale.

The paper by Mr. F. A. J. Fitzgerald, of Niagara Falls, on "Power in Electro-chemical and Electro-thermal Industries," may be characterised as a comparative study of the development of the electro-chemical and electro-thermal industries and of the general electro-chemical developments at Niagara Falls since 1895. The total consumption of hydro-electric power, Mr. Fitzgerald pointed out, had finally become stationary because, owing to popular agitation, the amount of water to be withdrawn from the Niagara had legally been limited, so that the increased demand for power could only be met by improved methods. There was also a prejudice that the energy was national property, and should not be exploited by private concerns. But the load factor of electro-chemical works, with their steadily increasing power demands, and of electro-thermal works, which showed an enormous though not long sustained rise after 1910, was very high, whilst the load factor of the public service was low. Very low power cost had lost its great importance for electro-thermal processes; other advantages more than compensated for the high cost of the heat generated in that way, and electro-chemical and electro-metallurgical industries afforded the best means for the wide distribution of the benefits of water power.

Mr. Torsten Holmgren, of Stockholm, claimed advantages for his "New Resistance Furnace with Reaction Zone," of which he spoke in very general terms, "not being in a position to give information about the chemical processes for which the furnace was intended." The furnace, he said, was evolved in connection with researches on nitrogen fixation conducted at Gothenburg. The material to be treated was a conductor of the second class, becoming a conductor of electricity at high temperatures above 600 deg. C. The furnace was a shaft furnace, rectangular in section; it was lined with electrodes on two sides, and provided with a horizontal grate. The briquetted charge sank slowly down in the shaft; gas would be liberated in the central reaction zone, and means were provided to preheat the charge in the upper layers and to cool it into lower layers; the former was attained by inserting a vertical auxiliary electrode into the upper portion and the latter by forcing gas upward through the grate. The furnace was worked at 950 deg. C.

In a paper on "Small Water Powers and Electro-thermal and Electro-chemical Loads," Mr. G. Boex, of the British Aluminium Company, Kinlochleven, urged the development of small water powers for the generation of electricity to be utilised in furnaces and electrolytic plants for the manufacture of chrome alloys, magnesium, zinc, abrasives, electrolytic iron, alumina cement, &c., and in steam-generating plants. Such small plants, he submitted, would often work more economically and dispose of their products locally to better advantages than large powers having to transport their

material over long distances. Mr. Boex gave comparative cost estimates for the production of a large variety of chemical and metallurgical products by direct or by alternating current, basing his estimate upon an average power cost of 5*l.* per kw.-year with a load factor of 75 per cent., as corresponding to average working conditions at Kinlochleven and elsewhere. He considered the products specified as particularly promising.

During the discussion of these papers Mr. Svenningson, of Shawinigan Falls, gave some particulars concerning hydro-electric development in the Province of Quebec on the St. Maurice river, a tributary of the St. Lawrence, where a 5,000 h.p. plant was started in 1900. By 1910, 100,000 h.p. were available for aluminium, carbide, &c. The Shawinigan Power Company now distributed over 200,000 h.p.; but the electro-chemical load had not risen in the period 1910 to 1918. The demand for power had afterwards become pressing; new plants were erected at Cedars and Grande Mère; the Canadian Electric Products Company and other works manufactured carborundum, aloxite, magnesium and steel, and by the end of 1918 the Shawinigan system supplied 105,000 kw. for electro-chemical purposes. The end of the war altered conditions again; but electric-steam boilers were put up, first in large paper mills, and nearly 120,000 kw. were now taken off the peak load for this purpose. Mr. Brooks, of the U.S. Bureau of Mines, asked whether they had had any trouble from explosions with these boilers. Mr. Svenningson replied that he had heard of such a case elsewhere, but their boilers were of transformer type, and they had had no complaints. Mr. Diény added that they had large steam-generation loads on three-phase systems also in France, but there had not been any explosions, though many forms of apparatus were on the market.

Mr. Horn, in closing the morning session, remarked that the summer peak was also worked in connection with the generation of steam in Kristiana, and in this and many other ways electro-chemistry would benefit the world.

The afternoon meeting, over which Mr. John Murphy, of the Canadian Department of Railways and Canals, presided, dealt particularly with "Power in Electro-metallurgy"; but electro-chemical questions came up again.

The first paper taken, on "Electrolytic Iron," by Mr. T. W. S. Hutchins, of the Electrobleach and By-Products Company, of Cheshire, was indeed largely, and might have been classified as, electro-chemical. Mr. Hutchins advocated the utilisation of electric power for making electrolytic iron, which, as tests conducted at the National Physical Laboratory confirmed, was of superior character; he went fully into the cost question. He described three electrolytic processes. The Société le Fer in France used soluble, cast or formed iron anodes, iron chloride as electrolyte and horizontal rotating cathodes; F. A. Eustis, in America, used insoluble carbon anodes and diaphragm cells and scrap iron or sulphide ore in the recuperator tanks oxidised by means of SO_2. In his own installation under erection, Mr. Hutchins used recuperator tanks to dissolve iron and also ore; then came filters and high cylindrical deposition tanks in which the suspended cathodes rotated, separated by a cylindrical diaphragm from the anode, which was the lead lining of the steel cylinders. The e.m.f. could be reduced to 1·5 volts, but working at 2·5 volts was cheaper. The acidity of the electrolyte (iron sulphate and sodium sulphate) should be low (equivalent to 0·0000158 normal sulphuric acid) to obtain smooth non-porous deposits; the filtering did away with many of the impurities and the hydrogen craters. More information was given on mechanical and metallurgical tests of the iron than about the electro-chemical features. Iron cylinders of the Société le Fer (several mm. in wall thickness) and of Mr. Hutchins, were exhibited. He also mentioned that the electrolytic iron first expanded and then contracted (between 400 deg. C. and 600 deg. C.) when heated, but this expansion curve of S shape was not observed when the heating was repeated. In reply to Mr. Boex, he said that the vertical cathodes were easier to handle than horizontal mandrels.

The paper on "Electro-metallurgy in Italy," by Dr. F. Giolitti, was mainly statistical and illustrated the remarkable recent development of the iron and electro-steel industry in Italy. While 12 firms made 20,200 tons of electric steel in 1915, 178 firms had produced 158,000 tons in 1923. Most of the special-steel plants of the war-time had been closed down again, but the demand for electric carbon steel was still high, and converters and crucible melting furnaces were inactive. The capacity of the Siemens-Martin steel works in Italy exceeded 2,000,000 tons. Whilst the world's production of electric steel went down in the period 1918 to 1922, from 1,200,000 tons to 500,000 per year, Italy increased her production from 74,000 tons to the 158,000 tons mentioned. Electric pig-iron had had an active period, in 1917 and 1918, when 62,000 tons were produced annually. It declined afterwards, but was now recovering. The plant of the Soc. G. Ansaldo-Cogne, for the treatment of the very pure magnetite from Cogne being now completed (after long delays), had installed six "Elektrometall" furnaces of 4,500 kw. Dr. Giolitti's paper was presented by Dr. Semenza.

Particular reference to these latter furnaces had been made in the statistical paper by Professor W. Palmgren, of Stockholm, on "The Electro-chemical Industry of Sweden," which had been taken, in the author's absence, in the morning. The "Elektrometall" furnaces of Grönwall, Lindblad and Stalhane, we may point out, are blast furnaces worked with currents of 15,000 amperes at 550 volts on 3-phase systems with three pairs of electrodes regulated by the phase currents. By reducing the charcoal charge to 40 per cent, Mr. F. Frieden, of Uddeholm, stated during the discussions of the afternoon meeting, the phosphorus percentage of the iron had been brought down to 0·008, most of that phosphorus coming from the charcoal and not from their pure ore. According to Dr. Palmgren, the various Elektrometall furnaces in Sweden total 43,700 kw.; the 40 Rennerfelt steel furnaces aggregate 8,000 kw.; there were further, Héroult and Kjellin furnaces, and many companies made ferro-alloys, including ferro-tantalum. The De Laval zinc furnaces were not yet economical; electrolytic zinc was not produced, nor aluminium. The carbide and cyanamide works at Alby are well known; alkalis, bleach, phosphorus and phosphates, chlorates and perchlorides, graphite, and also the electric steam boiler (of 3,000 kw. maximum) were all referred to by Dr. Palmgren.

The paper by Mr. W. Geyer (Germany) on "Electrical Engineering as a Leading Factor in the Development of Modern Steel Works," discussed the general uses of electric motors and their regulation for power production, cranes, air compressors and in rolling mills, especially in reversing mills; steel furnaces he considered fully to be able to compete with open-hearth furnaces when up to 5 tons capacity.

According to the last paper on the list of a statistical nature, by Mr. E. P. Mathewson, of New York, on "Power in Electro-metallurgy in the United States," electro-metallurgical processes are worked in more than 200 towns, steel refining (450,000 electric h.p.), ferro-alloys (150,000 h.p.), aluminium (350,000 h.p.), copper refining (75,000 h.p.), and brass melting (82,000 h.p.) being the most important industries. The most common steel furnaces are of the Héroult (166), Moore (52), and Snyder (51) types. Electrolytic iron is made by the Eustis and the Burgess processes; electrolytic zinc is practically made only in the Great Falls plant of the Anaconda Copper Company, though the zinc obtained is very pure. On the request of the chairman, Mr. Mathewson added some notes on the Cottrell dust and fume precipitation process which Cottrell had handed over to the Smithsonian Institute and a corporation for the benefit of scientific research. Mr. Hutchins regretted that the charges of the corporation were high. Mr. Murphy also gave figures on the electro-metallurgical industries of Canada; fertilisers were not made by electric processes.

Finally, Major H. Johansen, of the Norske Staal, Kristiania, presented a brief contribution on a new iron shaft furnace which had last month been tested in Trondhjem with good results. The iron ore was reduced by gas, and the CO_2 was reconverted into CO by being passed through the high-tension arcs (1 m. and more in length) which Schönherr introduced at Rjukan in 1905, and which are still in use there.

SECTION K1. POWER FOR RAIL TRANSPORT.

ON Wednesday, the 9th inst., section K1 of the conference met under the chairmanship of Mr. Roger T. Smith, to read and discuss several papers contributed on the above subject. The first paper taken was by Sir Philip Dawson, and entitled, "Financial Aspects of Main Line Electrification." In it Sir Philip pointed out that in this country the beneficial effects of suburban electrification had been clearly realised, but that in the case of our main lines the advantages were not appreciated as they should be. He knew of no scheme for general electrification worked out with such detail as that in connection with the electrification of the former London Brighton and South Coast Railway. For that reason the paper contained a critical comparison between steam and electric costs, the steam figures being based on the 1921 results of the company. Making allowances due to electrification, of an increase of 70 per cent. on suburban, and 35 per cent. on main line traffic, a return of over 8 per cent. on the total capital required to carry out the electrification was assured. The capital required for electrification of the complete suburban and main lines to Brighton and Worthing was 11,808,600*l.*, while for the year considered the gross receipts actually totalled 6,502,433*l.* under steam power. Those estimated under the new system reached 8,606,770*l.*

In his contribution, "The Electrification of the Austrian Federal Railways," Dr. A. Hruschka, of Vienna, pointed out that the loss of coal suffered by his country after the war rendered the electrification of lines necessary. The country's stock of coal would last only twenty years at full demand. The lines to be electrified totalled some 1,400 miles, requiring 330 millions of kw.-hour per year. Austria abounded in unexploited water power to such a degree that there were over 300 sources for the supply of the majority of lines. In the choice of system the Federal Railway authorities had followed the decisions in Switzerland and Germany, and intended to use single-phase current at a frequency of 16⅔ cycles per second with a pressure of 15,000 volts on the trolley wire and a transmission pressure of 55,000 volts, or, in several cases, 110,000 volts which would be stepped down in a number of sub-stations along the road.

Professor Charles E. Lucke, of Columbia University, New York, gave a paper on "The Internal Combustion Engine for Transportation." All internal combustion engines for transportation were of the petrol type, except in marine practice, where the oil engine overlapped in its smaller sizes and was supreme in its larger sizes. Motor cycles were typical of the smallest road transport vehicle. In 1923 45,000 were manufactured, embracing fifteen models, the engines with piston displacements ranging from 5·5 cub. in. to 79·4 cub. in. The greatest horse-power was reached in the four-cycle, four-cylinder, 2¾ in. bore, 3½ in. stroke, 3,800 revolution engine of 28 h.p. Automobiles came next in size and power. There were nearly 14,000,000 cars in the United States, of which 4,100,000 were farm owned. The average price per car taken over all makes was 811 dols. (185*l.*) during the year 1923, 70 per cent. of the types being six-cylindered. The horse-power varied from 25 up to 120. Truck and tractor engines, were mainly four-cylindered, operating with loads of 5 tons or more. Rail vehicles included both locomotives and self-propelled cars, although petrol locomotives, while developed in several standard designs, had so far been limited to the smaller sizes classed as industrial, and had not as yet become really important, as their work could usually be done about as well by trucks and tractors at a lower cost. Large passenger cars of 240 h.p. had, however, been constructed. With regard to marine requirements, solid injection heavy oil engines, working on the two-cycle system, commonly reached 450 h.p. with six cylinders. Air injection Diesel engines reached 3,000 h.p. working on the four-stroke cycle.

Mr. L. De Verebély, Consulting Engineer to the Hungarian State Railways, then read his paper on

"A New System for Main Line Electrification." Hungary's heavy losses of power at the end of the Great War rendered fuel economy imperative, and electrification offered a solution. This electrification throughout the country should be placed on a standard basis. To this end three-phase alternating current at 50 cycles had been decided on. It was desirable, too, that it should be possible to connect the railway load to any standard power system with the highest degree of economy, *i.e.*, with the least transformation, and especially without using rotating machinery in the sub-stations. To secure good characteristics throughout the large range of the different outputs required in traction services, the standard method of feeding the motors at a fixed pressure should be abandoned and the applied voltage varied with the load, according to the law $e = a\sqrt{W}$, where a is a constant and W the total input in watts to the machine. This law followed from the condition for a minimum total loss in the latter. To attain this regulation of the pressure a rotating auxiliary machine, *e.g.*, a motor generator, could be mounted on the locomotive and driven by the current drawn from the trolley. The field excitation of the generator side could be varied so that the pressures delivered to the main motors were in agreement with the law. An automatic field regulator could be built as a watt-meter, mechanically connected to an electro-dynamic voltmeter maintaining balance when $W/e^2 = $ constant. Such a rotating auxiliary machine on the locomotive could be used as a phase transformer converting 50 cycle single-phase current from the trolley to 50 cycle three-phase current supplied to the motors. This would permit of the economical single wire being used instead of the double arrangement necessary for electrified railways working on the three-phase system while still permitting the use of the three-phase locomotive.

The paper on "Power Questions Relating to Swedish Tramways," contributed by Mr. A. Hultquist, of Sweden, indicated the extent to which the natural water-power of the country had been utilised for tramway electrical supply. As a precaution against water shortage, steam or Diesel engines were maintained in the reserve stations of the country. All Swedish tramways were operated at 600 volts, except a few 1,200-volt lines, while all but five of the tramway administrations bought the energy in such a form that it could be directly employed for the cars, the remaining five buying three-phase energy which they converted into direct current before using. In 1923 the total energy consumption of the Swedish tramways was 35,442,857 kw.-h.

Dr. W. Wechman's paper on "Main Line Electrification on the State Railways in Germany" gave information on the work in that country. The total mileage electrically operated was 400, single-phase alternating current being used because this system was considered most suitable for main line work. Uniform trolley lines were maintained throughout the tracks and the latest locomotives were reduced to a few types of the simplest possible design. Telegraph and telephone lines were not interfered with, these operating in a quite satisfactory manner. The system was sufficiently economical to justify a percentage return of from 6·6 to 13·8 per cent. on the capital expenditure for electrical equipment.

Professor I. Franco, of the Netherlands Railways, contributed "Some Considerations on the Development of Railway and Tramway Traction." He stated that in connection with the steam system opinions differed as to the merits of the compounding principle for locomotives, but the necessity certainly existed for further economy than was permitted by existing engine design. For local tramway and railway locomotives, the petrol engine had already conquered a large field, and Dr. Franco thought that there was a possibility of the petrol 'bus being run on the railroad in the future, in which case, to avoid vibration, heavier cars would be necessary. At the present time there were running on the Dutch railways three petrol motor carriages over a nine-mile route between Kampen and Zwolle.

In his paper on "Application of Power to Rail Transport: Electric Railways in Great Britain," Mr. Roger T. Smith stated that in Great Britain coal was the main source of power, and its export almost paid for imported food. For our main line traffic it had not yet been proved that the cost of electricity was less than the cost of the coal burnt in the furnaces of steam locomotives, which it replaced, for the same haulage. Rather the reverse conditions held. Suburban electrification had been carried out mainly because the steam system could not cope with the volume of traffic, not primarily because of any monetary saving. At present there were on running lines 796·9 single-track miles; on sidings, 127·6 single-track miles; while the total mileage of single-track electrified was 924·48. Of this amount 856·8 miles of single track were suburban, 48·5 miles main line mineral track, and 19·2 miles experimental. An exceedingly comprehensive account of statistical details of working was given in the paper for the various electrified systems. From the Summary of Returns for 1923 it appeared that the total power generated for traction was 486 millions of kw.-hour; the sum of one hour maximum demands was 155,550 kw.; the annual maximum demand load factor for traction was 35·7 per cent.; and total output from sub-stations for traction 330 millions of kw.-hours. The total railway ton-miles worked electrically for the year were as follows: passengers ton-miles 4,703 millions; freight ton-miles, 78·5 millions.

Dr. G. de Gelder gave a paper on "Electrification of the Dutch East Indies," which discussed heavy traction in particular. He was convinced that the direct current system at either 1,500, 2,400, or 3,000 volts gave great economic possibilities when developed in conjunction with water power. Though the railways caused a big maximum load, the period of use could be made comparatively large. Usually the maximum load for traction did not coincide with that for lighting and power, so that the total loads could be held within reasonable limits. Dr. de Gelder had no difficulty in persuading the authorities to sanction the direct-current system, 1,500 volts being adjudged quite adequate. To supply this pressure two water-power stations were being constructed, the Oekroeg and Kratiak works respectively.

In the ensuing discussion on the papers read, Mr. Murray (U.S.A.) drew attention to the likelihood of train weights of 6,000 tons becoming common in the near future in his country. These would necessitate electrification, and he said, so far, progress in this direction had been rather slow. Since the 600-volt pressure was replaced by 3,000 volts the whole outlook had been changed, but financial inhibition still restricted progress. One difficulty arose worthy of mention. Electric locomotives were operative on their own lines only. This should be changed. The advantages of the universal applicability of the steam locomotive must not be forgotten. Professor Hele-Shaw then drew attention to the necessity of improving gearing to secure the highest efficiency. Lt.-Col. O'Brien stated that there was no call in England for the usual large-scale working essential for successful main line electrification. This made conditions difficult. Colonel Battie (India) pointed out the projected electrified services for Bombay lines on a 5 ft. 6 in. gauge, for heavy traffic, would utilise direct-current power at 1,500 volts. The pressure from the Tata hydro-electric stations near at hand was 100,000 volts. This would be transformed down as required.

The section met on the morning of the 10th instant under the chairmanship of Prof. Luigi Lombardi, of Rome. The first paper read, that of Prof. F. Tajani, explained how Italy used the overhead wire, direct current, constant-pressure system, with series excited motors, as a first endeavour in the development of electrification, in 1900. Later the three-phase system was extensively employed, since it was more suitable for traction purposes on main lines with considerable traffic, and it was now intended, after careful consideration, that this system should be used entirely in the future.

Mr. H. J. Schreiner, Electrical Engineer to the Norwegian State Railways, then gave a paper on "Electrification of Railways in Norway." He said that for many years to come the State authorities would require to concentrate their efforts on building the main lines which were still wanted, at the same time trying to reduce operating costs. Norway's abundant water power and lack of coal rendered it natural for the State to look to the former for a solution of the difficulty. The single-phase alternating current system, with pressures up to 15,000 volts and frequencies of $15,16\frac{2}{3}$ and 25 cycles, was general throughout the country. The disturbance to telegraph and telephone systems had been a question of great importance in connection with electric single-phase railways. When commencing electrification, lead-covered armoured cables were laid under the main roads, and by suitably balancing the inductive and capacitive relation between the wires in the cables, nearly all disturbances on the telephone and telegraphic systems had been done away with. When electrified railways approached the roads to avoid electro-magnetic induction, particularly by short circuits, it was necessary to make special arrangements in the distribution system of the railway. The first thing done was to reduce the short-circuiting current in the generators and transformers by suitable construction of these, as well as by suitable connections. Next, oil switches were used for each outgoing trolley wire, which broke the short-circuiting current instantly, or within 1·5—2 cycles. Finally, special boosting transformers were put up along the line. The distance between these was some 5 miles, and they were calculated in such a way that the leakage current could not exceed 960 amperes per mile, even with the most serious short circuit. These precautions had proved quite effective.

A paper on "Power Problems of the Swedish Railways," was read by I. Öfverholm, Electrical Engineer of the Swedish State Railways. In the single system electrified, namely, the Svartön Riksgräusen line, single-phase current at 15 cycles and 16,000 volts, was used for the contact wire, supplied from the Porjus hydro-electric station, on the Lule Älv. In this power station there were installed four single-phase generators for traction, one being used as a reserve. Each generator had a continuous output of 6,000 kv.-a. and maximum output of 10,000 kv.-a. The traction energy was generated at 4,000 volts, 15 cycles. Transformers with a 4,000 to 40,000 volts ratio fed the long-distance transmissions line at 80,000 volts; the transformers being connected in parallel on the low-voltage side, and in series on the high-voltage side. There were really two transmission lines, one line running north to Vassijaure, near Riksgräusen, and one running south to Notviken. The total length of transmission line was 320 miles. There were 15 sub-stations, about 20 miles apart. At each, two or three 80,000/16,000-volt step-down transformers were utilised for feeding the overhead contact wire. The transformers were rated from 1,100 to 1,500 kv.-a., and were oil-cooled and arranged so as to be easily sent by rail on a special car to the repair depots.

Section K.2. Power for Water Transport.

In opening the proceedings of Section K.2. on Thursday morning, the 10th inst., the chairman, Sir Westcott Abell, said that although more interest was displayed by the World Power Conference in the application of power to industrial purposes than to marine propulsion, a complete revolution in the world's activities had been caused by the marine application. It was easier and cheaper to transport ore and the other raw materials of industry to the places where fuel was available than to reverse the process. Without the influx of raw materials to this country the incentive to power production would be confined to the needs of mere existence. It was not only because of its higher heat value that oil was beginning to supplant coal in the service of power production for ship propulsion, but also to some extent by reason of advantages over coal in questions of economy of transport. Oil flowed to its work, coal had to be carried. Speaking as one associated with a very large international society connected with the shipping industry, he said, he would like to confirm what Lord Inchcape emphasised in his paper: that the co-operation of the principal interests in shipping, owners, shipbuilders and engineers, was of great value in the

efforts made to bring about improvement. This co-operation was not confined to Britain alone, but of late years had greatly increased in all maritime countries. Lloyds Register of Shipping had gradually established representative committees of shipping interests in the principal countries.

The important thing that must always be kept in mind regarding the provision of power for sea transport was that reliability was as significant a factor as technical or thermal efficiency. Progress of shipping was measured not only by the reduction of cost of fuel per ton-mile but also by reliability. In a paper presented to the section by Mr. Chalkley figures were given which showed the great development in motor engines for marine power. The increased demand was apparent, for it was stated that 11 per cent. of the ships under construction at the end of 1922 were motor driven, while the figure had reached 35 per cent. by the end of the following year. As an extension of the figures it might be said that the values for March and June, 1924, were 38·6 per cent. and 45·4 per cent. respectively. With the object of attaining the highest efficiency of a steam turbine and screw propeller some means of speed reduction was necessary. It was possible that in the future high-speed Diesel engines would be used with similar transmission gearing. For speed reduction the devices suitable for land installations were not always the best for use on a ship, as the conditions were very different. Auxiliary machinery for ships had to be strong and foolproof, and again the solution was not found by the mere adoption of land practice. It was probable that the most successful system of operating auxiliaries would be that which took into account the requirements aboard ship. In the opinion of many engineers the more rapid extension of the use of motor ships was prevented by considerations relating to suitable auxiliaries.

The Right Hon. Lord Inchcape, in his paper on "Shipowners and Shipbuilders," insisted on the necessity for co-operation between the two parties if improvements were to be effected. It was natural that a specific trade should evolve the type of ship necessary for its own requirements. An example was afforded by the present-day ships of the British India Company's Aronda class, by which the fast bi-weekly service for passengers and goods was maintained between Calcutta and Rangoon. It was clearly apparent that in steamers which constantly plied in tropical waters the passenger accommodation had to be specially designed. He then traced the influence of the character of trade upon types of ships. In the process of ship evolution two factors had constantly worked side by side. The first was the general practice of ship and engine construction, with all their successive improvements, and the second was the selective process by which special features and improvements of detail were introduced to carry on an individual class of work. The paramount consideration to the shipowner was the earning capacity of a vessel. While the shipowner had to depend on his knowledge and experience of ships, it was equally true that as regards the forces of propulsion and resistance, he had to rely upon the development work of the shipbuilder and his expert staff, and upon their familiarity with the two inter-dependent factors of power and modelling, and the multitude of considerations and details on which these factors depended. The improvements effected as a result of tank test work had given the shipowners a sense of security in accepting the shipbuilder's hull designs which was formerly denied to them. It was now possible to forecast the performances of a commercial ship in all varieties of trim with a degree of accuracy valued by the owners and those responsible for the navigation of the ship.

Mr. Basil Lubbock passed in review the history and development of the propulsion of vessels by sails. The difficulties of manning and the demand for large ships were responsible for the demise of the sailing ship. Five-masted square-rigged sailing ships up to 5,000 tons register had been launched and handled successfully, but that was about the limit with which the seamanship of sail could cope.

In a paper on "Sea Speeds and their Costs," Mr. Alexander Gray said it was the policy of the shipowner to gauge what was the probable demand for speed in his trade and build his vessels accordingly. As a mail liner cost anything from half a million to two or three million pounds, depending on her speed and size, and might require two or three years to build, it was impossible to meet suddenly any demand for unusual speed, whilst to provide greater speed than was requisite for the demands of her trade involved the owners in serious financial loss. The object of the paper was to show to what extent the public should be called upon to pay for speed apart from the service of transport. Voyage costs might be divided into general charges, such as wages, victualling, capital depreciation and interest which were influenced by time and tended to increase with a reduction of speed, and fuel costs which were decreased by a reduction in speed. There was some particular speed, which might be termed the natural speed, for each type of vessel at which the extra cost due to the one class of costs would outweigh the savings in the other. This natural speed would yield the greatest working efficiency, but the economic speed might be higher and would vary with the character of the employment.

The tramp vessel naturally showed the lowest speed. A cargo liner was usually of a superior type to a tramp and more expensive to construct and maintain, because she was required to take part in a service with some reputation for regularity, if not also for speed. Her economic speed was therefore higher than that of the tramp. The cost of this higher speed was met by better earnings, due to the carriage of the best cargoes. An intermediate liner was regarded as a first-class cargo vessel with the addition of passenger accommodation, which implied greater capital cost and maintenance charges with a consequent higher economic speed than that of the cargo liner. Except under special circumstances, the public did not pay for speed in the case of tramps, cargo, or intermediate liners. The mail liner was, however, different. Speed in this case was of vital importance, and as the higher speeds were attained the cost per knot increased out of all proportion to the increased rate of progress. The economic law of diminishing return operated so forcibly that the limit of speed at which ocean liners could be driven with any hope of commercial gain appeared to have been reached already on the North Atlantic route. Freight generally was of but minor help to high-speed ships, which could have but little capacity for anything other than specie, or time for its manipulation.

Mr. G. S. Baker presented a paper on "Hull Resistance and Power for Propulsion," in which he discussed the means of keeping the resistance down to a minimum compatible with the other conditions. The author assessed that the best speed at which a vessel could be propelled was that at which the cost of coal or oil burned in a day was equal to the profit earned by the ship in a day added to the capital charges for the same period. Such a speed should not be termed the economic speed, as it was not necessarily the most economical in regard to fuel. It was emphasised by the author that the economical size of a ship was not determined solely by the lowest ratio of coal consumed at some fixed speed to the cargo carried by the ship, nor by the ratio of deadweight capacity to loaded hull displacement. As far as these could be improved by alteration of design they were good, but to sacrifice cargo handling equipment or strength of hull for the purpose, or to reduce the ratio of power to displacement by enlargement of dimensions beyond certain figures, was anything but economical. The author then dealt with the various forms of resistance encountered by a ship and their relative magnitude. When propelling a ship the propeller worked in water already set in motion by the passage of the hull through it, and since this motion varied at different points around the stern, the conditions under which the propeller worked varied throughout the revolution. The greatest efficiency obtained was slightly in excess of 80 per cent., but in practice efficiencies in single and twin-screw ships were much nearer 65 or 70 per cent., the former being for full-ended ships and the latter for fine-ended ones. The propeller afforded possibilities of very profitable research work.

Mr. F. J. Leathers discussed the subject of "Fuels and their Supply for Sea Transport." Most fuels used for steam raising had, he said, been used at sea. The most noteworthy of these experiments were those concerned with various mixtures of pulverised coal and oil known generically as colloidal fuel. No patent fuel had, however, established itself, except in very special circumstances. There were still many anomalies in the regulations of public bodies in connection with the handling of oil fuel. Oil fuel was certainly not a dangerous commodity if properly handled and stored. Restrictive tariffs on oil in many places where coal was free of duty put a handicap on the use of oil fuel. Internal-combustion engines provided a more efficient way in which oil could be used for power production than burning it under boilers. The experience of the last few years showed that engineers were alive to the fact that one of their main problems was to make more and more possible the use of inferior grades of oil in internal-combustion engines. The daily fuel consumption of similar vessels of, say, 9,220 tons displacement, with a speed of 10¾ knots, was estimated as: reciprocating engines and water tube boilers, coal fired, 31·2 tons; similar equipment with oil firing, 22·4 tons; and, in the case of two-stroke Diesel engines, 8·2 tons.

Mr. Hector C. Bywater, in a paper on "Steam and the Measurement of Power for Sea Transport," sketched the history of the progress of marine engines and turbines, and referred to the conditions at the different stages in the development. Of the 679 ships belonging to Dutch owners, Mr. W. J. Muller said in his paper on "General Data on the Propulsion of Ocean-Going Ships in Holland," 601 were propelled by reciprocating engines, 38 by steam turbines, and 40 by internal-combustion engines. Superheaters were fitted to 142 steam ships. Of the 38 turbine-driven vessels, seven had single reduction gearing and 31 had the double reduction type. Little trouble had been experienced with either type. Nickel steel had been tried in the early Zoelly type turbines, but had not given complete satisfaction, and Monel metal and manganese bronze were now favoured. During the last decade water-tube boilers of the Howden and Babcock and Wilcox types have been installed. Trials had been conducted with mechanical stokers for marine boilers, but although some results had proved satisfactory, the development had still to be regarded as experimental. A Dutch cargo ship had been fitted recently with automatic stokers for all the cylindrical boilers and also with a mechanical coal conveyor. Most Diesel-engined ships belonging to Dutch owners had Werkspoor engines, but there were some of Burmeister and Wain design. The largest power produced per cylinder was about 400 i.h.p. Semi-Diesel engines of the Polar and Kromhout type had been in use for a number of years. The maximum horse-power of this type of engine did not exceed 500 per set of six cylinders.

Mr. A. P. Chalkley, in submitting a paper on "The Development and Present Position of the Motorship," said that although the history of the motorship commenced with the Selandia in 1912, it was undoubtedly true that much and valuable experience had been obtained with Diesel engines on smaller ships prior to that date. Since 1912 progress had been steady, although interrupted by the war, and the following figures showed the state at various periods.

Date.	Number of Motorships in Service.	Tonnage.
July, 1914	297	234,287
„ 1919	912	752,606
„ 1920	1,178	955,810
„ 1921	1,473	1,248,800
„ 1922	1,620	1,542,160
„ 1923	1,831	1,668,414

Of ships under construction the motorship tonnage was 10·9 per cent. of the steamship tonnage at December, 1923, 12 per cent. at March, 1923, 18 per cent. at June, 1923, 24 per cent. at September, 1923, and 35·5 per cent. at December, 1923. A large number had since been ordered, but were not included in the figures of the table, as they had not been commenced. They included 10 motor passenger liners of 158,000 tons gross, the largest being of 22,000 tons gross and having twin machinery of 20,000 i.h.p. The author then summarised the advantages of the motorship. The fuel consumption was 20 to 25 per cent. by weight of that of a corresponding coal-fired steamer, and between

35 and 45 per cent. of that of an oil-fired steamer. For equal dimensions and speed the motorship had a higher deadweight capacity of 5 to 15 per cent. A smaller engine-room staff was carried on the motorship, but the average pay was, however, higher, and the financial saving was usually not more than 5 per cent. Disadvantages of the motorship were the relatively high capital cost, the greater consumption of lubricating oil, and the limited supply of motorship engineers available.

Comparing two 10,000-ton ships in service, the motorship fuel cost was shown to be 46 per cent. of that of an oil-fired steamer, and considering exactly similar vessels of 450 ft. length running at 12 knots and having Diesel engines, coal firing and steam engines, and oil firing and steam engines, the daily fuel consumption was given as 17 tons, 70 tons, and 40 tons respectively. Typical cargo ships gave the following figures :—

Deadweight Tons.	Speed Knots.	Fuel Consumption per day. Tons.
14,000	12·5	21
12,350	11·3	16
10,000	10·6	10
9,300	11·1	11·4
7,500	10·5	9

In a paper on "The Four-stroke Type of Diesel Engine for Motorships," contributed on behalf of Great Britain, it was stated that for complete reliability, low upkeep, and small overhaul charges the four-cycle type of Diesel engine held an unchallenged position. Of the motorships now in service 80 per cent. had engines of this class. The proportion of two-cycle engined ships was increasing, but out of about 150 or 160 motorships on order between 110 and 120 would have four-cycle engines. Experience had shown that the desirable mean effective pressure was about 90 lb. per square inch. The four-cycle engine could be used at high speeds. In twin-screw installations, where a high speed could be adopted, the weight of four-cycle machinery could be reduced and the difference between it and the value for two-cycle plant was not of great importance. Four-cycle engines possessed the inherent advantages of effective piston lubrication and low lubricating oil consumption. In the four-cycle design, piston cooling arrangements were possibly of a kind which did not permit the leakage of the cooling medium into the crank chamber. In the two-cycle type the whole of the gear was internal except in the opposed piston design. Four-cycle engines had a lower fuel consumption than the rival type. In some two-speed, long-stroke, four-cycle engines recently constructed the consumption had not exceeded 0·38 lb. of oil per b.h.p.-hour. A comparison of weight was possible between the motorship George Washington with four-cycle engines and the Handicap with the two-cycle type. The former was 425 ft. length, 55 ft. beam and had a deadweight capacity of 10,800 tons. When carrying 9,500 tons an average of 11·8 knots had been maintained with Diesel machinery of 2,440 s.h.p. The Handicap was of 9,000 tons d.w., 415 ft. length and 54 ft. 6 in. beam, and had an estimated sea speed of 11 knots. Each engine of the George Washington type weighed 186 tons, compared with 168 tons for the Handicap.

The most recent development of the four-stroke type was in the application of the double acting principle. Three passenger liners in which machinery of this type was being installed were on order, and the engines totalled 20,000 i.h.p. on two shafts. In the new development of the four-stroke type the piston rod was entirely surrounded by a cooled cast-iron sleeve, protecting the rod from the gases and at the same time enabling a simple stuffing-box to be provided. The construction of double-acting engines otherwise was similar to that of the normal single-acting engine.

Mr. Robert Traill submitted a paper on "Two-cycle Diesel Engines," in which he claimed that the two-cycle system of working permitted greater simplicity of construction, and smaller dimensions and weights in relation to the power developed, than were possible with the four-cycle engine. Subject to the same main pressure being used, practically double the power could be obtained from a two-cycle engine as from a four-cycle engine of the same dimensions. Mean pressures of 100 lbs. per square inch could be maintained in a two-cycle engine with perfect safety. The weight of a four-cycle engine was from 30 to 50 per cent. greater than a two-cycle one of the same power and speed, scavenge and water pumps being included. The simplicity of the two-cycle design was most apparent in the construction of the cylinder cover, which was of simple cylindrical form, with a single central opening for the valve-box, ensuring perfect circulation of the cooling water and freedom from expansion strains, whereas the four-cycle engine cover was a complicated casting weakened by the large additional openings required for exhaust and induction valves and liable to set up cracks under working conditions. The cam-operated induction and exhaust valves of the four-cycle engine, together with their operating gear, were dispensed with in the two-cycle engine. While the temperatures of combustion of the two types of Diesel engines were about the same, the exhaust of the two-cycle was lower than that of the four-cycle because of the admixture of scavenge air and the water cooling of the bars between the exhaust ports. Considerable advantages were the more even turning moment and more effective starting of the two-cycle engine. Double-acting engines were in process of development, but the shipbuilders saw an objection in the increased height necessary. The engine which was simplest in construction would eventually hold the field, and it was maintained that the modern two-stroke cycle engine fulfilled the conditions more nearly than any other type.

In reviewing "Present Practice as Regards Application of Power for Marine Purposes in America," Mr. William T. Donnelly, after dealing with reciprocating engines and steam turbines, referred to speed reduction for driving the propeller by gearing, and the electrical method. If reduction gearing were to serve the purpose of transmitting any considerable amount of power with a large ratio of reduction, it must be made with enormous reserve power, or be provided with some intermediate means of limiting the stresses which would develop between the high speed of the steam turbine rotor at one end and the very slow rotating mass of the propeller at the other. With any considerable length of shaft between the two reacting forces the difficulty was aggravated. The electric plant surpassed all competitors in manœuvring power and overall efficiency, with the result that the United States Government adopted it for the propulsion of all warships of the super-Dreadnought class. The perfect flexibility allowed by the separation of the power generating and propelling machinery, as regards location and general arrangement, greatly facilitated the adaptation of the ship to various purposes. The remarkable progress made by the application of the electric drive was not to be taken, however, as a warrant that it would extend broadly or be adopted universally. The most promising field for development in ship propulsion was the study and application of the Diesel engine in association with the electric system of power transmission. In concluding, the author called attention to the necessity for developments in shallow water navigation, and to a scheme in which a single vessel provided electric power for a number of vessels in convoy.

Mr. W. J. Belsey advocated "Electric Transmission of Power for Propelling Machinery," dealing with the two cases where turbines and Diesel engines were used as the prime movers. The turbine equipment consisted of an A.C. generator suitable for direct coupling, a motor of suitable speed for the propeller, a D.C. exciter or an auxiliary generator from which direct current could be obtained, and suitable control gear. In certain types of vessels, such as battleships, where a cruising speed was required, the motor was generally made with change pole windings, giving two definite speeds at the propeller shaft for the one speed of the turbine. On account of the ease with which the arrangements were made for the change of the number of poles of an induction motor, this type was generally used for battleships. In merchant work only one speed of the propeller was necessary, and synchronous motors were preferred. The advantages of the system were reliability, simplified turbine construction, the astern turbine was eliminated, economy was obtained, there was an absence of vibration and noise, and the upkeep was small. The application of Diesel-electric drive had been made to smaller ships of which La Playa of 2,600 s.h.p. was so far the largest.

Mr. H. G. Hammar, a delegate from Sweden, submitted his paper on "Power for Ship Propulsion," of which we give an abstract on page 148 of this issue.

Admiral Sir Robert Dixon said that since Mr. W. L. R. Emmet gave a paper on the subject of electrical transmission before the Institution of Naval Architects just over a year ago, he had seen nothing tending to modify his view that the disadvantages in the case of warships were greater than the advantages. He was rather surprised at many of the claims made for the system. The fact that the astern turbine could be done away with was no doubt advantageous. He had seen many designs, and in every case the weight of the electrical transmission system was considerably greater than that of mechanical gearing. There was no point in the claim that repairs were eliminated, for that was the experience with gears in the Royal Navy. There was a better case for the Diesel-electric system for low powers, but even then the weight was high.

Mr. Belsey replied that the comparison of the weights of electric transmission equipment and mechanical gearing depended solely on the extent to which the gearing was stressed. In the paper read before the Institution of Naval Architects, Mr. Emmet admitted that there were many failures with gearing. After the Chairman had commented on the fact that single reduction gears only were used in the Royal Navy, Mr. Belsey said that the same experiences of failure had been found with the single as with the double reduction type. Admiral Dixon then stated that in the Navy they had between 600 and 700 single reduction gears, and the total number of failures could be counted on the fingers of one hand. These, however, were not complete failures, but merely small defects.

Mr. Chalkley assessed the losses in electrical transmission as 15 per cent. Although Mr. Belsey suggested that the higher propeller efficiency made up for this loss, if the case of La Playa was considered it would be observed that the propeller speed was 100 revolutions per minute, and with a direct drive the propeller would not be run at a higher value, so that it appeared that there was a direct loss of 15 per cent. with electrical transmission. When Mr. Donnelly dealt with the same subject, he gave figures for the weight of Diesel machinery which seemed too high. The motor ship was increasing in use at a rapid rate. In Sweden steamers were practically obsolete. Germany had 50 per cent. more tonnage of motor ships than steamships. The first Scott-Still engined vessel had given a fuel consumption of 8½ tons per day for an 8,000-ton ship running at 11 knots.

Mr. O. A. Wiberg contributed a paper on "The Reversing Clutch Marine Engine," reproduced in abstract on page 144 of this issue. The author described a reversing clutch for use with mechanical reduction gear. This included a fixed outer casing inside which was a revolving set of epicyclic gear wheels. The latter revolved with the intermediate shaft of the gearing when the propeller was working ahead, but remained fixed when going astern. The two conditions were obtained by means of two sets of disc clutches, one inside the casing and the other outside. The positions of the outer discs were regulated by four pistons, to which oil could be applied on either side. The first clutch turbine was installed on the t.s. Pacific, of Copenhagen, in 1920, and had been in continuous service since then. The consumption of coal amounted to 1·075 lb. per shaft horse-power hour, with fuel of a calorific value of 12,500 B.Th.U. per lb. Another reversing clutch described by the author combined the oil-operating clutch with an hydraulic gear, of which the action was similar to the Föttinger transformer, which was put into operation when going astern. A single regulating valve controlled the operations of both clutch and hydraulic gear.

Mr. Challoner called attention to the variety of equipments embraced by the term motor as used in the expression motor ship, and stated that definition was necessary in dealing with this class of vessel. In the development and progress of the oil engine many troubles had been experienced which had been overcome, and temporary expedients were

abolished when satisfactory solutions had been eventually found. A few years ago water injection into the cylinders was considered necessary; to-day it was thought absolutely dangerous. When coal was treated to obtained gas and oil, there would be an adequate supply of oil available, and the development of the oil engine would make rapid progress.

Lieut. B. R. Alexander said the electric drive was not universal in the United States Navy, and very few ships were so fitted, although they were the largest. In destroyers gearing had proved very satisfactory. Even for battleships it was admitted that the weight of electrical equipment was excessive, but it was being reduced. Induction motors were now made which weighed less than 8 lb. per horse-power, and the weight of switchgear was being reduced. The United States Navy weighed all the considerations, and decided that it was difficult to obtain, otherwise than by the electric transmission method, two economic speeds, one high for full power and one low for cruising. This demand did not exist with mercantile ships, as they were designed for full speed all the time. The electrical drive was capable of improvement, but it should neither be condemned hastily nor adopted generally. The adoption by the United States Navy was only tentative, and its continued application was dependent on their experience.

Dr. Kamo, a delegate from Japan, referred to the satisfactory experiences of electric transmission with the 10,000-ton collier Kamoi, built in the United States and equipped by the General Electric Company.

Mr. Belsey said the losses in transmission in the case of La Playa were about 11·5 per cent., and the Chairman pointed out that the equipment of the vessel was only decided upon in the quest for increased capacity within the ship, and had shown an advantage over the direct drive in that respect.

At the afternoon meeting, Mr. Russell Sinclair presided, when Mr. R. W. Allen presented a paper on "Diesel Auxiliary Machinery in Connection with Marine Propulsion." There was little doubt, he said, that the most efficient method of driving auxiliary machinery was that by which the power was obtained from dynamos driven by independent Diesel engines. All deck machinery, cargo winches, engine-room equipment, pumps for ballast, cooling, bilge, &c., and also the steering gear were now driven electrically. Diesel-engined vessels would gradually supplant steamers, and the tendency would be to rely more and more on Diesel engine-driven generators for the supply of power for auxiliaries.

Mr. H. S. Russell said that Mr. Hammar had spoken of supercharging for Diesel engines, but did not approve of the suggestion because it meant an increase of temperature in the cylinders. The temperature, however, depended solely on the compression ratio, and not on the original pressure of the air. They, therefore, had higher pressures with superchanging, but not higher temperatures. It seemed extraordinary that although the Diesel engine was first used on board ship to drive auxiliaries, when the propulsion was obtained from the same type of engines, steam plant had been used for the auxiliaries. One difficulty with Diesel ships was the contamination of fuel oil and lubricating oil with water, the results of which might be disastrous. It was a growing practice, therefore, to install centrifugal oil separators on board ship for use in removing the moisture, as well as other foreign matter from oil.

Admiral Sir Robert Dixon said he thought it advisable to point out some of the defects of the Diesel engine. The Navy had been pioneers in its use both for auxiliaries and for propulsion. The power from such an engine was small. They would eventually have satisfactory double-acting two-cycle engines, on the subjects connected with which much research work was being done. The Diesel engine had the disadvantages of being of the reciprocating type, and, therefore, caused vibration, the power was limited, the weight and the space occupied were high, the noise of operation was excessive, and there was far too much complication in its construction. He was forced to the conclusion that geared turbines for high powers would not be replaced by Diesel engines. For low-powered vessels there was, however, an opening for the Diesel engine.

Mr. Hammar said the experience with supercharging was that the engine power could be increased by 20 per cent., but they had to use higher temperatures than could be considered safe. In regard to auxiliaries for motor-ships they were working on two lines:—complete electric equipment, which was very costly, and the use of exhaust gases in boilers to generate steam for auxiliaries.

Prof. E. Hubendick, of the Royal University of Technology, Sweden, said that although the temperature in an engine cylinder did depend on the ratio of compression, it should not be forgotten that with supercharging in use more oil was used and there was a higher temperature, due to the presence of the greater quantity of combustible.

Mr. Alexander Gray said that it seemed to be the case that electric auxiliaries were best, but it must not be forgotten that it was necessary to have some steam available on a passenger ship for the baths.

SECTION N 2. STANDARDISATION.

Members who assembled at the advertised time of 1.45 p.m. for the discussion of the subject of Standardisation on Thursday, July 10, found that the meeting had been deferred until 2.45, when the Chairman, Sir Archibald Denny, opened the proceedings. The attendance was by no means large. Ten papers were before the Conference, namely, "Standardisation—National and International," by Mr. C. le Maistre, Secretary of the British Engineering Standards Association; "International Standardisation in the Field of Power," by A. E. Kennelly (U.S.A.); "Proposal for Uniform Rules for Testing Water Power Plants,"* by G. Sundby (Norway); "Standardisation in Austria," by Dr. J. Tomaïdes (Austria); "Industrial Standardisation in Sweden," by A. Kruse (Gen. Secretary of Swedish Standardisation Committee); "Standardisation in Germany,"† by Dr. F. Neuhaus (Germany); "Etat Actuel des Co-opérations Techniques Internationales," by Dr. Guillaume Exner (Austria); "Electrical Standardisation in the Dutch East Indies," by C. D. Volker (Government Bureau of Water Power and Electricity in Dutch East Indies); "Standardisation and Control of Electrical Acessories and Household Appliances," by H. Grosch (Norway); and "Considerations as to the most Economical Ratio of Increase in a Series of Standardised Main Dimensions," by Dr. J. Goudriaan.

The papers, the nature of which can generally be inferred from their titles, were taken as read. Mr. Le Maistre pointed out the benefits of standardisation and the advantages of a central organisation for this class of work. As regards the direct financial value of standardisation to industry, he mentioned that the first work undertaken by the British Engineering Standards Association in 1901 was the standardisation of rolled sections, which first reduced the different sizes from several hundreds to 195; more recently the number had been brought down to 113. This reduction was estimated to save five shillings per ton in manufacture. The original 75 sections of tramway rails had been reduced to four standard sizes. International standardisation was a very difficult matter, but the secretaries of the various national standardising bodies, now numbering eighteen, which had been created since the war, were in constant communication with each other, and by this means a large amount of international uniformity had been brought about. The International Electrotechnical Commission, organised in 1906, was working in conjunction with 24 national committees, which were the most appropriate bodies to deal with details, leaving the Commission to deal with such things as terms, definitions and symbols, all of which enter so largely into international intercourse.

Dr. Kennelly's paper indicated the nature of the work done by the International Electrotechnical Commission, and thought that it would be desirable for the World Power Conference to take steps to join in the standardising work of the Commission. He discussed the language difficulty, and pointed out the necessity of a clear understanding that when a difference of opinion arose as to the meaning of a resolution drawn up in the two official languages (English and French), only one language must be taken as the ultimate standard. With regard to units, Dr. Kennelly wanted Great Britain and the United States and all the other English-speaking countries of the world to conform to the metric system of weights and measures. He also considered that it might be advisable to drop the British thermal unit and measure the heat value of fuel in kilowatt-hours. The "horse-power" was "a very unscientific unit," and it was desirable that it should be replaced by the watt, kilowatt, myriawatt, or megawatt, as occasion demanded. With Dr. Kennelly's preference for expressing all angles decimally instead of in degrees, minutes and seconds, there is, we think, much more to be said. His opinion that it would be desirable to employ the same methods of power-plant book-keeping in various countries also deserves consideration; even if we could be sure that the system was properly standardised in each country it would be something.

In his paper on "Industrial Standardisation in Sweden," Mr. A. Kruse states that the Swedish Industrial Standardisation Committee was formed in 1922, and had so far approved of sixty standards mostly in relation to bolts, nuts and screws. Among these, however, is a standard for "lettering on drawings"—a subject which may be commended to our own committee with special reference to architectural drawings. Mr. C. D. Volker pointed out the importance of standardisation to countries like the Dutch East Indies, far from the works of manufacturers. Standardisation would allow the stocks to be carried by merchants to be greatly reduced, and apparatus therefore cheapened. In the Dutch East Indies, three-phase A.C. current at 50 cycles is standardised for main transmission and distribution systems. Alternating current voltages are standardised at 127, 220, 380, 6,000 and 30,000 volts and direct current at 110, 220 and 600 volts. There are numerous secondary standards.

The standardisation of mechanical details in Germany was dealt with by Dr. Neuhaus in a paper reproduced elsewhere. The Standards Committee of German Industry, formed in 1917, obtained funds from contributions from the industry, and from the sale of publications. There was no subsidy from the Government. One of the subjects of standardisation by this committee had been commercial papers, letters, journals, drawings, &c. Each size was obtained by doubling or halving the area of the next below or above it and all sizes were similar in shape. The basis size was one square metre, with sides 841 mm. by 1,189 mm. By halving this size four times the business letter size, namely, 210 mm. by 297 mm., was obtained. Numerous companies had adopted this size for their correspondence and about 50 technical journals were about to adopt it. In Switzerland, Austria, Hungary and Czechoslovakia the size had been adopted, and Holland and Sweden would shortly follow. Dr. Neuhaus devoted a little consideration to the subject of "preferred numbers" in establishing standards having a uniform increase per step. This question was considered mathematically in considerable detail by Dr. J. Goudriaan, who took into account the factor of economy, balancing the desire of the manufacturer to have few sizes with large steps between, and the interests of the consumer who did not wish to buy something larger than he actually wanted.

In opening the discussion Sir Archibald Denny expressed the opinion that it would be a pity to erect any new organisation to deal with Standardisation as an International Commission already existed. Dr. Kennelly thought it desirable that the meeting should formulate a resolution on the subject, and he moved that "The meeting recommends that the World's Power Conference does not engage directly in standardisation but prefers that all such matters be dealt with by the appropriate body or bodies." Mr. Miles seconded the motion, remarking that standardisation work could not be undertaken by a body created in a moment, and it would take the World's Power Conference several years to get together the organisation required. Dr. Semenza, President of the International Electrotechnical Commission, supported the resolution declaring that the Commission would be glad to undertake the work. Mr. Morton said that there

* Reproduced in abridged form on page 145.
† Reproduced in abridged form on page 149.

did not appear to be any international body taking care of mechanical as contrasted with electrical standardisation, and a new body should be constituted, or the scope of existing bodies broadened. Dr. Kennelly said that all energy was one and the same thing, and that the appointment of any other international standardising body must overlap with the work of the International Electrotechnical Commission. He moved that the wording of the resolution before the meeting should be somewhat altered, the sense, however, being apparently unchanged. After Mr. Brooks had referred to the necessity of standardising symbols, &c., in connection with steam power plant practice, Mr. Kapp called attention to the extreme desirability of an editorial unity in connection with standard specifications, so that all should be similar in form and arrangement. If different bodies were engaged on the work, this unity would vanish, with a consequently great increase in the trouble of consulting specifications. The chairman then put a resolution to the effect that the World Power Conference should not engage directly in standardisation, and this was unanimously carried.

Section N 3. Technical and Commercial Education.

This section met on the morning and afternoon of July 10, under the chairmanship of Mr. F. V. Hansen (Sweden) and Professor J. W. Roe (U.S.A., Industrial Engineering Department New York University) respectively.

Dr. A. P. Laurie and Professor F. G. Bailey, respectively Principal and Professor of electrical engineering in the Heriot-Watt College, presented a paper on "The Training of the Apprentice," in particular in the engineering trades. Premising that the cost of a good training is so small a fraction of the increased value of the work subsequently produced that expense is not of primary importance provided a distinct improvement is achieved, the authors discussed in general terms the lay-out of an apprentice's education that would provide the necessary training, and in a short appendix gave particulars of what is—and is not—being done in some large English towns. The large majority of workmen who would formerly have earned their living by craftsmanship have relatively little need of it under modern conditions, when in most trades the machine provides all the skill that the operation requires. Most workmen, in fact, will be occupied with machinery, and should be educated to that end, bearing in mind, as war experience with women and others showed, that a few weeks' training is enough to enable a suitable person to pick up all the skill that is required for operating many important machines. What is necessary is to give every worker a more developed intelligence and judgment, a better general education, and as much vocational training as can be imparted in a school, including some knowledge of the scientific foundations of engineering work. The authors traced the sort of curriculum that would be necessary to satisfy these conditions. In their view, it meant that primary education on the lines they suggested should be continued to the age of 15, and the years of vocational training should follow before the beginning of apprenticeship. In the first two years half the time should be spent in the technical school and instructional workshop, where the apprentice would best learn the use of machine tools and other fundamentals of workshop practice, so that when he enters the works he would be immediately of real use. It is thus of the utmost importance that his apprenticeship should be a real teaching of the trade, and that he should not be regarded as a source of cheap labour to tend automatic tools, a process that morally has as bad mental results as child labour has physically. How school and works should be divided between these two years was of relatively small moment; whether by half days, alternate days, weeks, quarters or half years. By scholarships and otherwise opportunities should be provided at various stages for suitable boys to have more elaborate education; so much as the paper outlined should, however, be supplied to all boys, and public control over education should extend to the end of the five years' apprenticeship.

Mr. A. P. M. Fleming read a paper on "The Training of the Engineer of the Future," referring in particular to those intended for professional or directory positions. An engineer must have the ability not only to use tools but to get things done, to look ahead for possibilities beyond those which are evident from existing facts. Teachers must learn to detect the possession of such ability in their boys. Technical training in the universities does not succeed sufficiently in eliminating those who are not fit to become engineers, and should give a much more comprehensive and fundamental study of physics, on which future progress in engineering is likely to depend. The present training fails notably in fitting men to think logically and independently, and to face new situations without consulting precedent. It would be a good thing for the engineering staffs of universities to migrate from time to time to engineering factories, so as to develop a facility in applying technical principles to the solution of practical problems. The student also should proceed early into industry, where the firms themselves are providing courses of training to enable him to decide the branch for which he is best suited and to make a special study of it. It is after his apprenticeship is over that post-graduate work is most useful, and it would be worth the while of firms to give the training of their apprentices a clearer objective than is often done, and to couple it with incentives such as are offered at universities. Post-graduate work and an extension of travelling scholarships could then be undertaken with the prospect of turning them to the best advantage. Throughout the entire course the process of weeding out should be maintained, and constant attention given to the cultivation of personality, energy and character. Whether the methods of vocational selection may ultimately be a sufficient guide is not yet established firmly enough to enable a safe judgment to be passed on the fitness of men for work without observing their individual behaviour during training. In some fashion or other attention should also be paid to a good general education.

Mr. J. C. W. Reith read a paper on "The Influence of Broadcasting," in particular in respect to education derived from the experience of the British Broadcasting Company, and described a variety of ways in which radio telephony could be used to enrich the school and the home, from concerts and scientific lectures to church services. In the discussion on this paper Mr. Easton (U.S.A.) gave particulars of the development of broadcasting in the United States, and Mr. W. J. Brown (Metropolitan Vickers Company) of the consequences to be expected from recent technical progress, such, for example, as the possible adoption of English as an international language.

Mr. Burroughs (Great Britain) described several useful applications of broadcasting that were being made. Apart, for instance, from general talks on rural subjects, such as egg-laying and the diseases of poultry, or of the Ministry of Health on appropriate subjects, quite topical information will be given, such for example as the condition of a given crop of fruit at the moment, the probable effect on markets two or three weeks later, and the best immediate treatment to give to the crop.

A paper by Professor A. Van Royen (Holland), on "The Education of the Engineer in the Netherlands and their Colonies," was taken as read. It dealt with the development of higher technical education in Holland, and described in particular the higher technical schools at Delft and at Bandoeng (Java). The system adopted was to confine instruction to the purely scientific foundations of engineering, and to leave the innumerable details of application to be learned in the shops.

Mr. N. Fredriksson (Sweden) read in abstract a paper on "Elementary Engineering Education," tracing the history of the several Swedish institutions for the purpose from the end of the eighteenth century onwards.

Dr. H. M. Pleijel and Professor C. Hallendorff (Sweden) read in abstract papers describing respectively the arrangements of the two higher technical institutes in Sweden and of the institutions for commercial education. The former, like the Dutch, concern themselves principally with giving a sound scientific foundation for the subsequent study of applied sciences, including more than the sciences associated specially with the branch of engineering that the student is taking up. Commercial instruction includes teaching both during and after school age, many of the institutions being supported and controlled by the State.

Mr. Zur Nedden read a paper by Professor Conrad Matschoss (Germany) on "Co-operation of Industry with Technical Schools," urging that such co-operation is indispensably necessary. A great deal has been and is being done in this direction, notably by the Dtsch. Auschuss f. techn. Schulw., Sommerstr, 4a, Berlin, N.W. 7, which is issuing a compendium of special courses for the different engineering trades, so planned as to serve as a model for individual firms, which can modify it to suit their own special conditions. This Committee was founded by the Society of German Engineers and the Association of German Machine Manufacturers, and now includes all circles in Germany interested in technical education. The training courses of the Committee consist primarily of representative drawings made so as to be intelligible to engineers of all countries. They are prepared in accordance with the principles of the German Standards Committee, and the text has been settled after long negotiations between the interested parties. Intended originally for apprentice training, they now go further, and constitute a great compendium of technology, which is of value to the mechanical engineer in productive work. New methods are communicated to the Committee as far as possible. On information supplied by a large German firm, instruction tables are being issued for various engineering trades, consisting of drawings which illustrate side by side the right and the wrong way of doing particular operations, with a brief explanatory text. Engineering institutions and the technical journals which many of them publish, take a further important part in reconciling scientific knowledge with practical experience, and amount, in fact, to correspondence schools on a large scale. Particular attention is also given to the health and physical soundness of pupils in shop schools, which are now being conducted by a great number of firms.

A report by the Esthonian Minister of Trade and Industry on "Technical and Commercial Education in Esthonia," was taken as read. It gave particulars of the types and number of schools, the majority of which are quite independent of the State. The number of professional schools is steadily increasing, and their development is receiving the attention of the Minister of Education.

In the course of the general discussion Mr. Green (Canada) described the practice of consolidated schools, by which education was conducted in the large territories and sparse populations of West Canada; districts combining to provide omnibuses to take children from their homes to a City school. The University of Saskatchewan provides courses for farm boys of 16 years and over during the months of November to March. In these they continue their general education, and in the engineering, blacksmiths' and similar shops receive instruction in practical work, such as repairs, trials, taking to pieces and assembling common machines, and so forth. Similar courses are taken by men of all ages.

Professor F. G. Baily (Great Britain) deprecated making research a necessary element of the curriculum, partly because there is not enough apparatus for everyone, and partly because everyone is not fit to use it for the purpose. The disposition of manufacturers to demand men who are immediately useful was dying out. They ask rather that a man should have had a good general education on fundamentals, and preferred themselves to teach him what he required to learn of the trade. To teach practice in college was waste of time, for when a man went into the shop, practice might have changed, especially by the time he attained a position of responsibility. What was wanted was that he should know enough to be able to carry on his own education through technical journals and otherwise after he left his technical school.

Professor Joseph W. Roe (U.S.A.) said that on the whole industrial leaders in the United States were not satisfied with the results of present methods of technical education, some finding that men had not acquired a sound knowledge of the foundations of pure science, and some that they had no sufficient equipment in any branch of practice to be able to

OXYGEN JET CUTTING MACHINE.

CONSTRUCTED BY THE GODFREY ENGINEERING WORKS, WOOD GREEN, LONDON.

(*For Description, see Page* 124.)

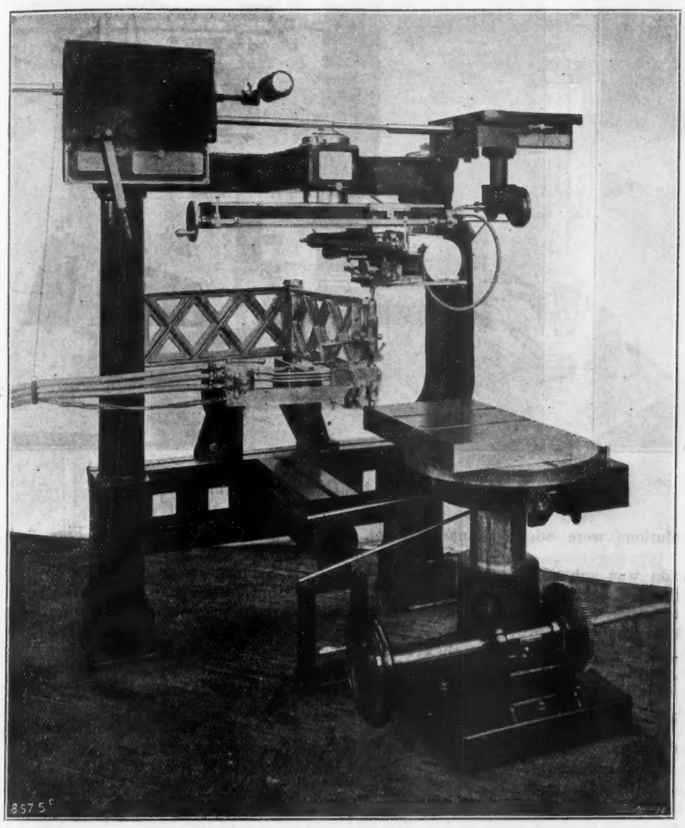


FIG. 1. GENERAL VIEW OF MACHINE.

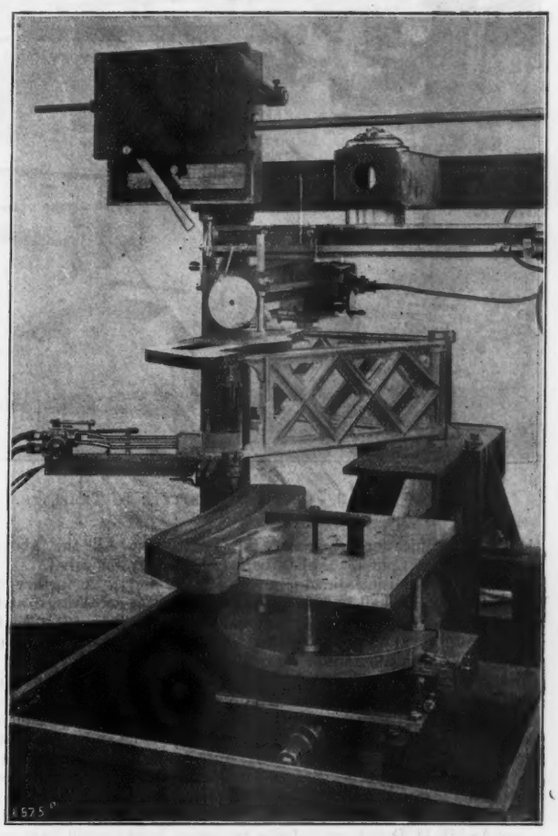


FIG. 2. CUTTING LINKS TO TEMPLATE.

be used with profit without further education, a criticism which had a tendency to lead to overcrowding the curricula. The most hopeful results appear to have been obtained from the co-operative plan initiated in 1906 by Dean Herman Schneider in the University of Cincinnati. This system is very similar to the Glasgow sandwich system, except that it maintains close supervision over students while they are in the works, inviting them to submit reports on a large variety of questions connected with the shops in which they work during their periods away from the college, these reports being read both by the University and the works authorities. The men work for wages at rates agreed with the University, and in all respects are under regular shop discipline. As a rule they return to the same shops during the whole of their course. The period of alternation varies from one week to four months. In New York University, where the system has now been introduced, the engineering course at present extends over four years, but an alternative five-year course is now being introduced. In the University of Cincinnati, where the system has been longest in operation, a co-operative course was taken at the outset in 1906 by about a quarter of the students. The proportion increased rapidly, till in 1909 there were over twice as many co-operating students as regulars, and by 1920, when the faculty had grown to some eight times its numbers in 1906, the regular students were so few that classes for them were discontinued.

Mr. J. Paley Yorke (Great Britain) protested against the unsatisfactory state of technical education, and urged that it was now time to inquire into the relations between technical education and industry, an inquiry that had not been held for over 40 years. Mr. Wickham Murray (Great Britain) urged the need for co-operation between industry and local educational authorities. The enormous development of machinery had practically abolished apprenticeship in most branches of the engineering trades. There was, however, a growing demand among working men for a wider education than they obtained, framed to satisfy their desire for information on subjects of their own free choice, and means must be found for providing it. Mr. Stevenson Taylor urged that throughout the courses of the technical schools the need for safety should be taught, which would affect both engineers who planned the buildings and those who designed machines.

Mr. Zur Nedden, referring to Prof. Roe's observations, said that the goal of a technical university was not to make ready-made engineers, but to teach them on the one hand the fundamentals of their profession, and on the other hand, how to learn quickly, so that as occasion may arise they could learn to apply what they knew to whatever might be their job for the time being. In Germany the first two years were given to mathematics, physics and machine construction, In later years they specialised in design, workshop superintendence, testing or administrative and economical engineering, the curricula being framed accordingly. Similarly in the trade schools, in the first years the teaching was general, in the later specialised, and in all years attendance at the municipal course was compulsory unless the firm provided adequate instruction. After four or five years' service, apprentices were often exchanged with apprentices from other works, a practice that showed a marked tendency to broaden their minds and the extent of their knowledge.

GENERAL MEETING.

A general meeting of the Conference was held on the morning and afternoon of July 11, under the presidency of Mr. O. C. Merrill (U.S.A.), the Executive Secretary of the Federal Power Commission, and of Mr. Hugo Hirst, vice-president of the Beama, respectively, to undertake "A Review of Sessional Activities and Consideration of Future Possibilities." Delegates from twenty-one of the States represented at the Conference delivered final reflections on its work, in which they testified generally to its importance and success, and to the admirable way in which it had been organised by Mr. D. N. Dunlop and his staff. A memorandum and series of resolutions approved by the International Executive Committee were submitted to the Conference. The memorandum laid down in general terms the importance of continuing the work of the Conference, and of considering the advisability of forming a suitable permanent institution at a later stage, inviting each constituent country to create or maintain for this purpose a permanent representative National Committee. The present International Executive Committee are to carry on, for the time being, necessary work arising out of the Conference, and each country is to keep in touch with the International Committee either by appointing a delegate of its own National Committee or otherwise. Within a reasonable time the International Committee is to take into consideration the line best calculated to further the objects of the Conference, with a special regard to avoid interference or overlapping with the functions of any existing international organisa-

OXYGEN JET CUTTING MACHINE.

CONSTRUCTED BY THE GODFREY ENGINEERING WORKS, WOOD GREEN, LONDON.

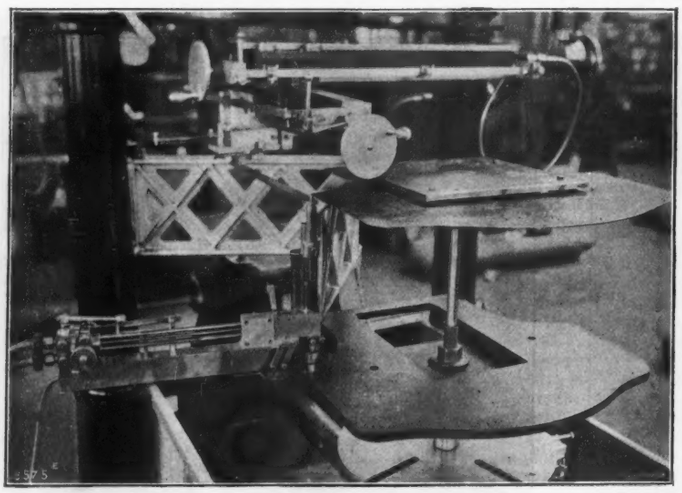


FIG. 3. CUTTING HORNPLATE TO TEMPLATE.

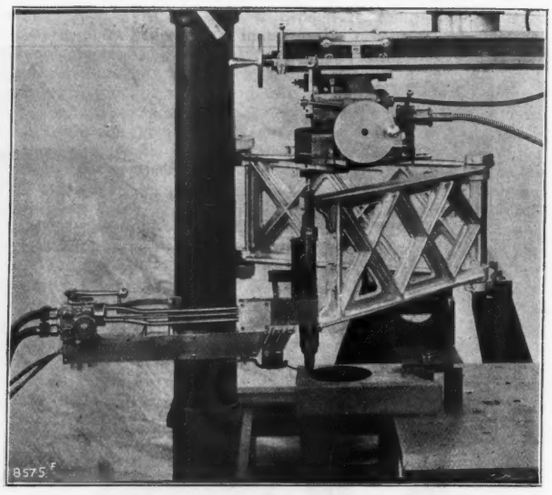


FIG. 4. CUTTING CIRCULAR HOLES.

tion. Communications between the constituent countries of the Conference shall be maintained by the present organising director and his staff, and the next meeting shall be held at a time and place to be determined by the International Committee with the approval of the respective National Committees. This memorandum was adopted unanimously, successive speakers pointing out the wisdom with which it abstained from precipitate action, to which, indeed, delegates had no authority to bind their countries, thus giving the more hopeful prospect of constituting ultimately a permanent body, should it appear that the required work cannot be done by some existing International authority.

Sir Archibald Denny presented a resolution from the Standardisation Section, urging that the Conference should make no attempt to standardise, but should act through existing bodies, there being already eighteen National Standardisation Committees in existence. The resolution was received without dissent, and referred to the International Executive Committee. A special resolution, moved by representatives of Great Britain and the United States, urged the indispensable need of greater production and manufacturing activity, and the importance for this purpose of the fuller developments of national power resources and the most economical distribution and utilisation of energy. Mr. Atkinson, in moving the resolution, pointed out that the rate of manufacture was in danger of greatly outstripping the rate at which raw materials were won. Increased production of raw materials would be followed naturally by increased demand for manufactures, but unless the balance between production and manufacture was restored, the world's manufacturing population would most certainly run short of material, and the standard of living would inevitably fall. It was essential, moreover, that increase of manufacturing activities should not be made in congested cities, but should be distributed where a fair allowance of light and air could be had, and for this purpose the most economical generation and distribution of power was indispensably necessary. Other resolutions recorded the thanks of the Executive Committee to the authors of papers and the chairmen of Sections. The visiting delegates recorded their appreciation of the manner in which the Conference had been organised and conducted by Mr. Dunlop and his associates, and their appreciation of the courtesy and hospitality they had received. The British Executive Committee offered its thanks to the officials and Secretaries of National Committees and to delegates for their effective co-operation. All the above resolutions were adopted unanimously.

A further resolution was submitted on behalf of France and the leading continental nations to the effect that the adoption of the metric system would promote industry.

Mr. Lowell (U.S.A.) moved a resolution that the International Executive Committee, after inquiring the cost of acquiring Heathfield Hall, near Birmingham, the final home of James Watt, and ascertaining the willingness of constituent bodies to contribute to its acquisition, should take appropriate measures to acquire and preserve it as a public possession for the benefit of the entire world. Mr. Lowell said that future generations would gain much more than the cost when in the improved conditions that had resulted from Watt's work they were able to see with their own eyes the conditions in which he himself lived, and the little garret workshop that he used to the end of his days.

Resolutions of thanks were adopted unanimously to be forwarded to H.R.H. the Prince of Wales, and Lord Derby, the President of the World Power Conference, for their participation in its proceedings.

THE GODFREY OXYGEN JET CUTTING MACHINE.

As a workshop process the cutting of metals by the use of an oxygen jet in association with an oxy-acetylene heating flame has much to recommend it. In addition to simple straightforward work which might be performed, but with less speed, by a saw, there are more or less complicated shapes which must be cut, for which there is no other tool than the oxygen jet suitable, or the work is such that it can only otherwise be done with a considerable expenditure of time and labour. Once it is recognised that the cutting of regular or irregular shapes with precision is now possible in an easily manipulated machine, new fields of service for this cutting process will become at once apparent. The Godfrey oxygen jet cutting machine was designed by Mr. Alfred Godfrey of the Godfrey Engineering Works, Boundary Road, Westbury Avenue, Wood Green, London, for the purpose of combining cutting with precision and working with any type of template. The manner in which the machine was devised to meet these requirements may be seen from the construction of the actual machines, two models of which with details of the important features are illustrated on this page and pages 123, 125 and 134 of this issue.

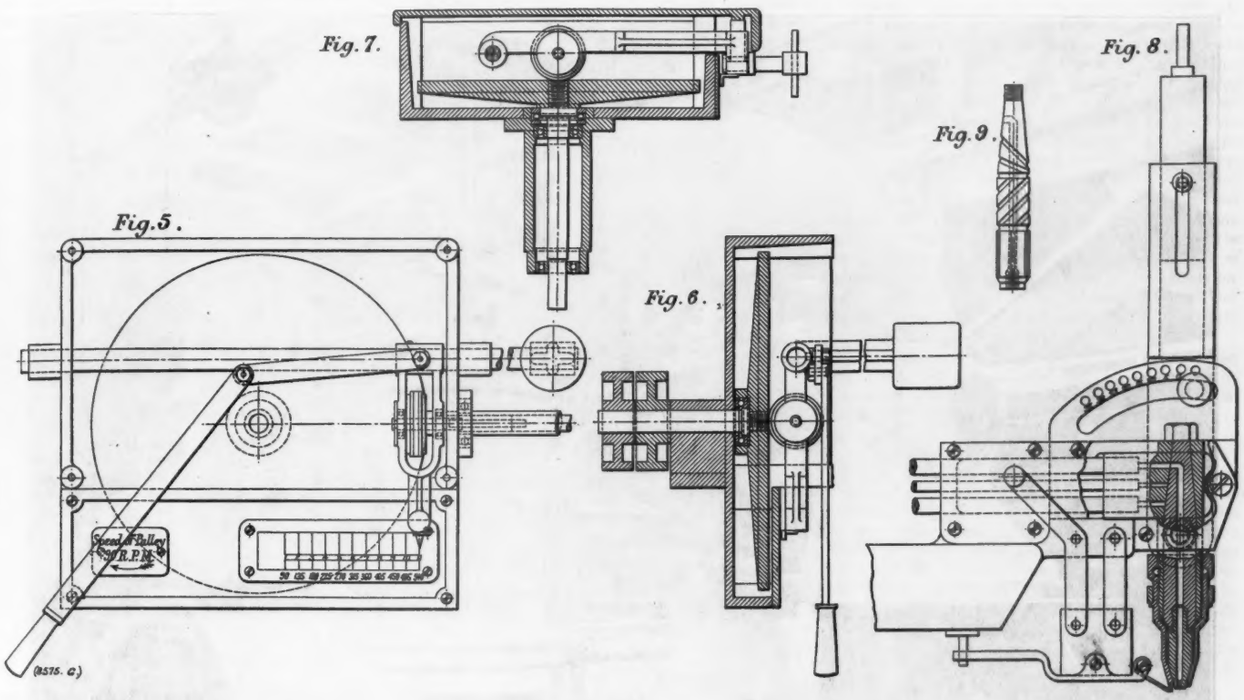
Fig. 1 shows a small machine, while Figs. 2, 3 and 4 illustrate its use in cutting the link of a valve motion, cutting a hornplate and making circular holes. The cutting blowpipe is attached at the end of a jointed arm made up of two aluminium castings, hinged together, and supported on one of the side members of the frame. At the top of the frame the drive mechanism is situated. An electric motor of $\frac{1}{4}$ h.p. is all that is required to operate the machine, which is made as frictionless as possible by the extensive use of ball bearings. A main disc, which is driven by the motor, is provided with a roller attached to a shaft, which conveys the rotation taken from any position between the centre and outer edge of the disc to another similar disc at the other side of the frame. Here also is a roller to obtain an infinite speed variation. From this roller the motion is taken by flexible shafts to the two slides above the oxy-acetylene burner. Knock-off motions are fitted to the two slides to ensure easy setting for the performance of any type of work. All the motions for the burner are obtained through the main disc, and the motion can be controlled by the adjustment of the hand lever, which determines the position of the roller on the disc. In order that the operator may have exact knowledge of the speed at any moment, a calibrated scale is mounted below the roller and an index is provided for the scale by an extension of the frame which holds the roller. The details of this part of the mechanism are shown in Figs. 5, 6 and 7.

For cutting in straight lines the longitudinal and transverse slides are used, movement on which is made possible by a flexible drive to the screws within the slides. The stops upon these slides are useful in the production of rectangular figures. For cutting irregular figures to template the burner is attached to the end of a lever, and is held by springs against the template which is attached to the spindle which passes through the centre of the rotary head. Templates of wood, vulcanised fibre or metal may be used, and as the top end of the burner is made to traverse round the pattern, the completed work is formed true to shape and dimensions. Some indication of the variety of template working which is possible is afforded by the illustrations, Figs. 2 and 3. The table for the accommodation of the work is separated from the main frame in order that large work may be done. Circular holes can be cut by housing the top end of the torch in a radius arm rotated by the drive, and graduated so that the proper dimensions may be obtained, Fig. 4.

The construction of the burner and the cone within it may be seen from Figs. 8 and 9. The cone has

OXYGEN JET CUTTING MACHINE.

CONSTRUCTED BY THE GODFREY ENGINEERING WORKS, WOOD GREEN, LONDON.



its main oxygen passage cut through the centre, while effective mixing of the oxygen and acetylene for heating is obtained at the junction of two helical grooves, through which the gases pass, in the coned part at the top. Further progress is made through helical grooves cut in the other direction, and the final passage to the outlet is by vertical slots in the cone. The circular opening for the heating mixture of gases is caused by the motion of the surrounding sleeve, which is obtained through movement of a graduated ring. It is therefore possible to open the burner to just the extent requisite for effective heating, and it remains in that position when once set. Electric ignition is provided for the jet as a convenience and a time saver. It will be noted from Fig. 8 that tilting the torch to various angles is possible, so that plates may be cut with a caulking angle.

The large machine shown in Figs. 10 and 11, on page 134 is fitted with similar gear to that of the smaller model, but the location of the components is not identical. The small motor is situated in this case on the carriage beside the speed control gear, and the flexible shaft drive is carried over to the cutting equipment. In the body of the carriage, which runs upon rails, there is accommodation for many bottles of gas for use in the cutting work. This machine was designed for use in long work, such as locomotive side frames. The suspension of the beam system is clearly shown in Fig. 10. The burner is moved to and fro by the motions obtained directly from the template. The flexible drive is taken in this case to a small suspension link carrying the spindles of a gear wheel, which can be made to drive either the longitudinal or traversing motions or be set in such a position that no movement takes place. The simple movement of a single small lever is thus all that is necessary to stop the motion or to start it at times to suit the conditions of working. The capacity of the machine, as far as length of work is concerned, is only limited by the lengths of the rails that are provided, and thus exceptionally long work may be performed on plates of any usual thickness.

The control of the motion of the torch in both these Godfrey machines is so easy that perfectly regular cutting is made possible, and momentary variation to suit the work may be made instantly to suit the varied shape, and so obtain uniform motion of the torch no matter what part of a curve is being cut. Indeed, the motion is so easily controlled and the jet, once set, works so uniformly that the completed work has a degree of finish which is quite unusual. For most purposes for which metal is cut no necessity will be found to finish in any way the surfaces left by the torch.

HYDRO-ELECTRIC POWER DEVELOPMENT IN NEWFOUNDLAND.

AMONG the important hydro-electric schemes being carried out at the present time is an interesting one in the Humber River district of Newfoundland, where the continuous output of 100,000 brake horse-power will be utilised in paper mills of the Newfoundland Power and Paper Company, Limited, and for lighting and heating the new township of Corner Brook. The work is being carried out by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, London, who are also manufacturing the turbines which will be installed at the site. Through the courtesy of Messrs. Armstrong, Whitworth we are able in Fig. 1, page 126, and Figs. 2 and 3, Plate XIII, with this week's issue of ENGINEERING, to give some views of these turbines in the builder's shops, while Plates XIV and XV illustrate several general features of the scheme, some of the electrical gear being illustrated in Figs. 10 to 15, Plate XVI, and page 127. We may mention incidentally that the whole development scheme forms the subject of an interesting exhibit in the Newfoundland Building at the British Empire Exhibition, where there is to be seen a model of one of the large turbine sets.

The map, Fig. 4, Plate XIV, shows the Humber River district where the scheme is sited, and indicates its main features. The work involves the construction of a dam at Grand Lake, canal, with intake works, forebay, and pipe lines to power house, and further two transmission lines to Corner Brook, where the mills will be situated, the site being visible in the general view, Fig. 5, Plate XIV. The area of Grand Lake, originally 130 sq. miles, will be increased to 150 sq. miles, the elevation being raised from 346 ft. above sea level to from 370 to 377 ft. The catchment area of Grand Lake of 1,650 sq. miles, gives an annual average flow of 5,000 cub. secs. The storage now being provided, and amounting to 30,000,000,000 cub. ft., will ensure a continuous flow of 4,000 cub. secs. The outlet from the lake was originally by way of Junction River, into Deer Lake, which stands at an elevation of 110 ft. The natural difference in level between these two lakes is thus 236 ft., which will be increased somewhat by the storage scheme. The dam under construction across the Junction River is illustrated in Figs. 8 and 9, Plate XV. It will permit surplus water to flow by the old channel. The main canal takes off from the lake at a point about 2 miles west of the dam, and crosses a depression which has involved the construction of stretches of embankment. Fig. 7 illustrates the longest trestle fill at Glide Brook, which will be cut, a new lake being formed in the artificial basin thus formed. The down-stream eastern end of the canal is shown in Fig. 6, Plate XV. In order to facilitate the excavation and construction of the main dam, a temporary crib dam was constructed some distance up-stream of the permanent site, at a point, shown in Fig. 4, where the Junction River leaves the lake, and the water was diverted from the site.

The main dam is of the hollow type, about 1,000 ft. in length and 75 ft. high from foundation level. Its construction has necessitated the diversion of the Newfoundland Government Railway from Port-aux-Basques to St. John's, a 3 ft. 6 in. gauge line. This diversion is indicated in Fig. 4. The line will cross the Junction River on the top of the dam, thus avoiding the need for a special bridge. The two views we give of the dam were taken at some months' interval, Fig. 8 having been taken last year, while Fig. 9 shows the more advanced state of the work this season. The spillway for water level regulation consists of 18 electrically-operated sluices each 15 ft. wide. The maximum discharge during flood time will be about 26,000 cub. secs.

Water for the power plant is conveyed from the

14,000 B.H.P. TURBINES FOR THE DEER LAKE POWER STATION, NEWFOUNDLAND.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, ELSWICK.

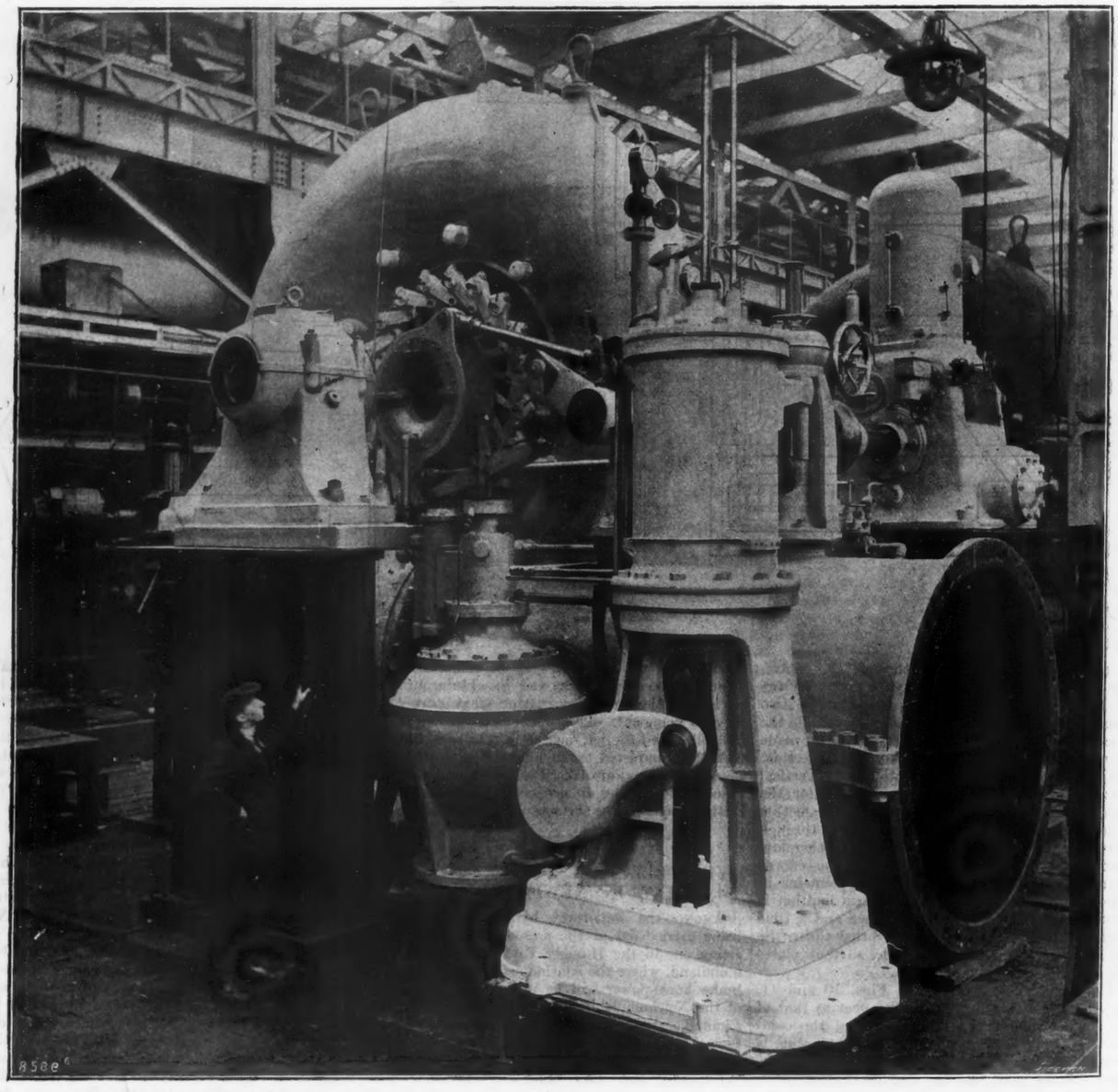


FIG. 1. SUPPLY SIDE OF TURBINE, SHOWING BUTTERFLY VALVE AND OPERATING GEAR, RELIEF VALVE AND GUIDE VANE GEAR.

lake by open canal as far as the forebay, intake regulating works being provided in the easternmost of the two sections, into which the canal is divided by the new lake formed in the depression referred to above. The intake works comprise five sluice gates, each 22 ft. wide by 15 ft. high. Each is fitted with two bronze screws, operation being by electric motor arranged with automatic self-resetting limit switches, or by independent hand-gear in case of emergency. The distance between Grand Lake and Deer Lake is about 8 miles, and in order to take advantage of the best alignment the canal, as mentioned above, passes through a depression which is shown as Glide Brook Lake. This has necessitated the construction of two lengths of embankment, one having a length of about 4,400 ft. with a maximum height of 35 ft. (Fig. 7), and the other about 950 ft. long with a maximum height of 75 ft. These have been constructed of material excavated from the canal. By this means the total length of canal excavation was shortened by some 2½ miles.

The forebay is situated at the down stream end of the westernmost section of the canal, and comprises seven sluices each 12 ft. square, controlling the supply of water to the pipe lines. The gates, which are of steel, are fitted with rollers and bronze rubbing strips, and are operated through a single screw by means of electric motors. Portable hand-gear is also available. Ice is prevented from entering the penstock by an overhanging curtain wall and steel trash rack. Each pipe line is provided with an automatic trip gear which operates if the velocity in the pipe should exceed a certain limit as a result of a burst, &c. Seven pipe lines convey water from the forebay to the power house 260 ft. below, arrangements being made for two additional lines to be laid at a later date if required. A log chute of steel plate and angles runs from the forebay to Deer Lake.

The pipe lines are each 4,000 ft. in length, the upper 2,500 ft. being of wood stave construction and having an internal diameter of 9 ft. 6 in., while the lower section is of riveted steel plate. The wood stave portion is carried down to the head of 170 ft. and comprises 150,000 cub. ft. of timber and 2,000 tons of steel bands. The riveted pipes are 9 ft. 6 in. at the upper end, reducing to 8 ft. 6 in. at the bottom. These, weighing about 4,000 tons, have been manufactured at the firm's Walker Shipyard.

The power station on the shore of Deer Lake is 387 ft. in length by 60 ft. wide. The main equipment consists of seven 10,250 kw. alternators, each with direct coupled exciters, and driven through rigid flange coupling by a horizontal shaftspiral casing Francis turbine, designed to give 14,000 brake horse-power at 375 revolutions per minute, with net head of 250 ft. An efficiency of at least 91 per cent. is anticipated from these turbines as a

result of model tests. The shafts of all units will be placed in single line and parallel with the length of the power house. The turbine runners are each 57 in. in diameter, and consist of a cast steel hub and discharge ring, with forged mild steel plate buckets cast into them. The spiral casing is made in three sections, together weighing 25 tons. A cast-steel butterfly valve, hydraulically operated, is flanged to the horizontal section. The views given in Fig. 1, page 126, and 2 and 3, Plate XIII give an excellent idea of the turbines. Fig. 1 shows the inlet, and the butterfly valve just referred to will be seen inside the pipe, while its operating gear is in the immediate foreground. This view also shows the guide vane control, while the governor gear is on the far side of the supply pipe. The governor is again shown in Fig. 2, which also illustrates the turbine on the side of the discharge bend. Fig. 3 is another view showing the guide vane gear, and, below, the butterfly valve operating gear.

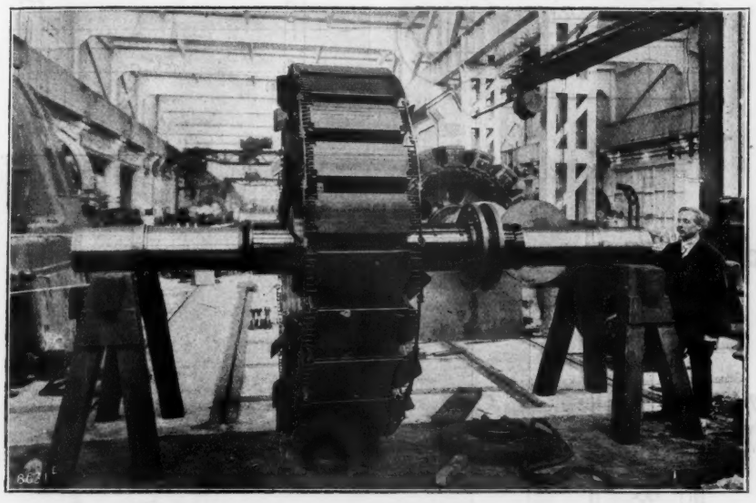


FIG. 15. ROTOR FOR 2,600-H.P. MOTOR FOR PULP GRINDER.

The turbine shaft is carried in two bearings, one of the pedestal type with a spherically seated liner, the other being mounted on the discharge bend, as shown in Fig. 2. This combines with the journal bearing a Michell thrust bearing to take care of any unbalanced hydraulic thrust. Each unit has an automatic governor of the self-contained type with compensated relay valve controlled by the centrifugal action of a weight mounted in the belt pulley. Oil circulation is maintained by a rotary gear pump. A large pressure accumulator is mounted above the governor case, with which are cast integrally the twin servo-motor cylinders operating the governor shaft. To this shaft are also connected the governor-operated pressure relief valves arranged on either side of the turbine casing. The connection may be well seen in Figs. 1 and 3. A 20-ton flywheel, 12 ft. in diameter, consisting of a cast steel rim and boss bolted to two boilerplate discs, is inserted between the coupling flanges on the ends of the turbine and generator shafts. Flywheels of this type are not usual in such units, the flywheel effect provided by the rotor of the generator usually proving sufficient to ensure good control. In this particular case a flywheel was made necessary by the severe conditions for automatic regulation, resulting from the 4,000 ft. pipeline for a head of 260 ft. The flywheel effect required was found to be about three times as much as would be provided by the alternator rotor itself. The conditions might have been somewhat improved by the use of a surge tank, but no such tank could have been sited near enough to the power house to eliminate entirely the use of a separate flywheel. These special features made the horizontal shaft arrangement imperative. The turbines and their gear have been constructed at Messrs. Armstrong, Whitworth's Elswick works.

The generators, switchgear, &c., have been supplied by the British Thomson Houston Company, Limited, of Rugby, this part of the installation comprising seven 3-phase, 50-cycle alternators, step-up 3-phase transformers and 66,000 volt switchgear. Current will be generated at 6,000 volts and stepped up to 66,000 volts for transmission to the step-down sub-station at Corner Brook. The transformers are being supplied by the Canadian General Electric Company of Toronto. The seven main generators have a rating of 10,250 kv.-a. at 95 per cent. power factor, 6,000 volts, 50 cycles. They have 16 poles and run at 375 r.p.m. These machines are illustrated in Figs. 10, 12 and 13, Plate XVI. The laminated steel poles are securely fastened to the central steel hub, giving ample strength even under runaway conditions of the turbine. Ventilating air is supplied through ducts in the foundations. Each alternator has its own direct coupled exciter, the latter being controlled by Tirrill regulators. The step-up transformers are of the 3-phase water-cooled type of the same rating as the alternators, one transformer being connected directly to each alternator to raise the voltage from 6,000 to 66,000 volts. Fig. 14 shows one of the 66,000 volt 3-phase oil circuit breakers which are of the explosion pot type. The generation of gases when the circuit is interrupted is confined to the inside of the pot, the expansion of the gases causing a rapid interruption of the circuit, the outer tank of the switch being relieved of excessive pressure. In Fig. 14 one of the oil tanks is lowered to show the contact rods and explosion pots. The power will be transmitted to the mill at Corner Brook, a distance of about 32 miles, by four 3-phase 66,000 volt circuits. The conductors are steel cored aluminium, carried on lattice steel columns, with pin type insulators. There will be two lines of towers about 400 ft. apart and the spans will vary between 350 ft. and 400 ft.

At the mill sub-station the 66,000 volt current is connected up to duplicate bus-bars controlled by circuit-brakers and isolating switches of the same make and type as those in the power house. From the main bus-bars the power is supplied to three secondary bus-bars through transformers made by the Canadian General Electric Company. One set of bus-bars operates at 4,400 volts, and is supplied through 12 single-phase 4,000 kv.-a. transformers. This supplies current for electric boilers in the mill. Another set operating at 2,200 volts is supplied through six single-phase 5,500 kv.-a. transformers, and controls the power for nine large synchronous pulp grinder motors, two of which are being supplied by Messrs. Crompton, of Chelmsford, and seven by the British Thomson Houston Company. The same bus-bars also supply several large induction motors for the paper machines. The third set of bus-bars operating at 550 volts are supplied through three single-phase 2,000 kv.-a. transformers. This supply is used for motor generator sets for current for lighting and small motors, &c., at the mill. Features of this installation are the separate exciter bars supplied by three motor generator sets from the 2,200 volt bus-bars, and a starting bus-bar supplied by two compensators.

The nine large synchronous motors of 2,600 h.p. each, designed for 2,200 volt 3-phase 50-cycle current, are of the type illustrated in Fig. 11, Plate XVI, and Fig. 15 annexed. They work at 231 r.p.m., and are rated at 3,100 kv.-a. at 67 per cent. leading power factor, in order that magnetising current shall be available at the mill for magnetising the step-down transformers, induction motors and other apparatus. Consequently this magnetising current does not flow over the main transmission line which operates at practically unity power factor. By adjusting the excitation of the synchronous motors the voltage at the mill can be kept approximately constant under conditions of varying load. The illustrations of the electrical gear are from photographs taken in the builders' Rugby works, and in some cases show temporary arrangements adopted for testing purposes.

Practically the whole of the mill, covering about 12½ acres, is built on reclaimed ground formed by half a million cub. yards of earth fill. The output of the mill will be 120,000 tons of newsprint paper per annum, requiring the supply of 200,000 cords of wood, which will be brought to the site by rail and water in lengths of about 12 ft. During winter as transport by water is impossible, in order to ensure continuous operation supplies will be drawn from large storage areas near the mill. After having passed through the slasher house, where the logs are sawn into lengths of about 4 ft., they are conveyed to and from the store by belt conveyor to the pulp mill. Pulp will be made both chemically and mechanically, the two products being mixed in the proportion of 25 to 75. The wood-pulp grinders are driven by the motors illustrated in Figs. 11 and 15, and already referred to.

Four 234-in. paper machines are being supplied by Messrs. Charles Walmsley & Co., of Bury, Lancashire, who are members of the Armstrong group of firms. For heating the rolls of these machines about 200,000 lb. of steam will be required per hour. This will be supplied by two 25,000 kw. electric boilers, supplemented by four Babcock & Wilcox fuel-heated boilers. For subsidiary machines about 270 motors will be installed, ranging in capacity from 3 to 400 b.h.p. Two large store buildings having a capacity of 40,000 tons of paper are built on the foreshore, where two berths have been provided for vessels, served by railway sidings, &c. The housing of the operatives has involved the construction of a new town, which will contain all necessary public buildings, schools, &c.

ALKALI WORKS IN 1923.

IN the sixtieth Annual Report on Alkali Works for the year 1923, Dr. T. Lewis Bailey, Chief Inspector under the Alkali Act, regrets that he is not yet able to chronicle any definite general recovery in the heavy chemical industry. There had indeed been an exceptional activity in the tin trade, but in the superphosphate industry and in some other branches the position was unfortunate. In alkali and copper (wet process) works only a small portion of the plant was in steady operation, partly because hydrochloric acid was more and more made synthetically from the electrolytic gases, and the export of cement was much restricted. The further extension of the use of sulphur (instead of pyrites) in the manufacture of sulphuric acid was making less material available for the wet extraction of copper. So long as first cost and manufacturing advantages remain favourable, that practice is considered likely to continue on account of the increased output realisable in a given plant unit of the direct production of an acid practically free of arsenic and of the absence of troublesome residues. New types of plant were being designed to reduce installation cost. One more works had adopted electrostatic dust deposition in connection with a chamber plant, thereby obtaining a perfectly clear Glover acid, which was hitherto impossible. Plant maintenance had, in general, been very satisfactory. Mechanical sulphur burners were coming

more into use, but mechanical salt-cake furnaces were not making much headway.

As regards the washing of the residual gases of the lead-chamber process, Messrs. John Miller & Co., of Aberdeen, we see, have introduced a promising novelty. They feed the second Gay-Lussac tower with a limited quantity of water (360 gallons daily), instead of 31 tons of strong acid. Among the advantages claimed are less pumping of strong acid, diminished acidity in the exit gases and a gain in the recovery of sulphuric acid; an exit test of 1 grain acidity means a loss of more than 70 tons of strong acid yearly. In Scotland, low-temperature distillation is extending fast, because the demand for tar for the repair of roads provides a market at the door while transport cost of the crude tar to the professional distillers is high. When the tar distillation is completed, trouble sometimes arises from the coolers—the closed tanks in which the hot pitch cools before flowing away to the pitch bay. There is considerable leakage and fire risk unless the tank rivets are kept under constant supervision. A fatal accident to two men who were repairing the eighth tar still of a block while work was going on in the seventh, would not have occurred, according to Mr. J. W. Young, the inspector for Scotland, if repairs of this kind had been forbidden unless the adjacent still was also idle.

The chief inspector does not consider the complaints about nuisances to have been excessively numerous, although strong pressure had occasionally to be exerted. Petroleum refineries had also become a source of nuisance because they discharged their waste gases from the distillation of crudes directly into the atmosphere; as in the previous year, moreover, six works were found operating without having registered under the Act. The treatment of the effluent from sulphate of ammonia and gas liquor works, which has claimed the special attention of Dr. Bailey and his assistant, Mr. Linder, of late years, again forms a large portion of this year's Report. There is, it would appear, a marked difference between the liquors from horizontal and from vertical retorts. Only the former liquors can be dephenolated in the towers which, on the suggestion of Dr. Bailey, were introduced at the Hornsey Gasworks, where these problems are being particularly investigated. The latter liquors contain so-called dihydric and trihydric phenols (*i.e.*, benzenes with two and three hydroxyl groups, instead of the one hyhroxyl of phenol) and also much thiosulphate and thiocyanate. Such liquors become strongly decolorised in faintly-alkaline solutions and they absorb more oxygen than others, and for these reasons sewage, with which they are mixed, is not fit for ordinary biological treatment. It has been found at Rothamsted, however, that certain micro-organisms of the soil destroy these complex phenols and sulphur compounds. There would hence be no particular difficulty in treating town sewage, contaminated with such affluent, on the land; but the chemical problems require further study.

SCIENCE AT THE BRITISH EMPIRE EXHIBITION—V.

THE exhibit of the Metrology Section of the National Physical Laboratory includes apparatus showing how the end standards that have to be used in practice for most purposes are calibrated with the fundamental line standard. The collection begins with a facsimile of the standard yard in form and material; a bar of Baily's metal (copper 16, tin 2½, zinc 1) of 1 in. by 1 in. section, with lines defining the yard length engraved on gold plugs sunk near each end of the bar with their surfaces on its neutral axis (Fig. 46). The bar is supported on eight equally spaced rollers, and the load is divided equally between them by a system of levers.

As yet no satisfactory apparatus has been devised for comparing directly, to the necessary order of accuracy, the length of an end gauge, such as must be used for most practical purposes, with that of a line gauge, though line gauges can be compared with line and end gauges with end. The comparison, therefore, of line with end gauges has to be made indirectly, and one of the methods is shown in Fig. 47. It depends essentially in preparing a composite gauge, which, with two movable ends, can be used as a line gauge and with one as an end gauge. To express, for instance, the length of what purports to be a 36-in. end gauge in terms of a line standard, a gauge rod of length g, about 35½ in. long, with accurately parallel ends, has wrung on to it at either end two block gauges of identical length, which can be manufactured with an accuracy of the order of 0·000001 in. Each of these block gauges has a line ruled across it, and the distance between the lines in the composite gauge is compared with a line standard in a line-standard comparator. The blocks are then turned about and the measurement repeated. The first measurement is thus $g + b + c$, the second $g + a + d$, and the mean $g + \frac{1}{2}(a + b) + \frac{1}{2}(c + d)$, or, as the two blocks are of equal length, g plus the length of one block. The length of a composite end gauge made up of g with one of the blocks wrung on to one end is therefore known in terms of the line standard, and this gauge can be used as an end gauge in an end-gauge comparator for measuring the 36-in. end gauge of which the line-standard length is required. From a 36-in. gauge so calibrated, end gauges measuring sub-multiples of a yard can be derived. Thus, three 12-in. gauges can be made of equal length, to be passed when their combined length is 36 in.; 4 in. can similarly be derived from 12 in., and so forth.

A difficulty in making these gauges is to harden the ends without disturbing the internal equilibrium of the bar and setting up strains that may distort it. This has been got over by using the resistance furnace shown in Fig. 48. In this, the end rod from which the gauge is to be made is suspended

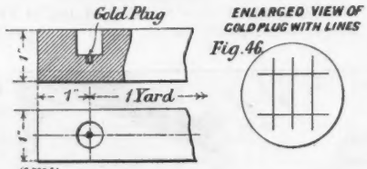
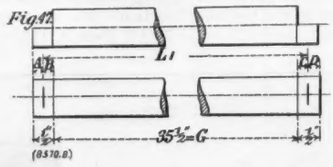


Fig. 46.

Fig. 47.



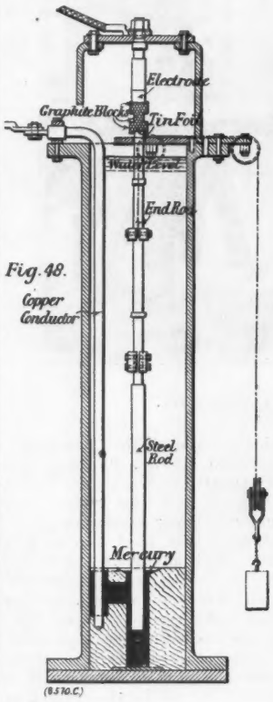


Fig. 48.

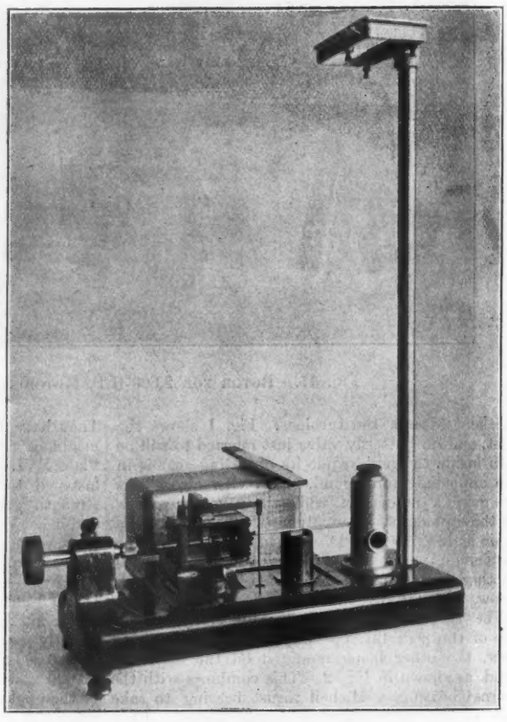


FIG. 49. HORIZONTAL END-GAUGE COMPARATOR

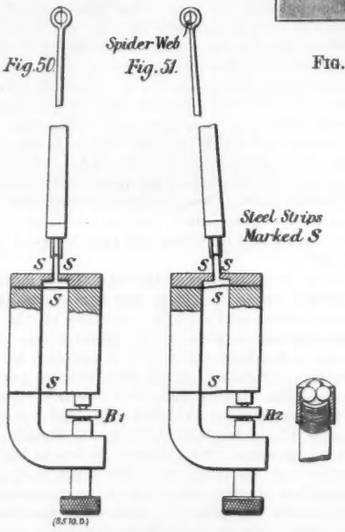


Fig. 50. Fig. 51.

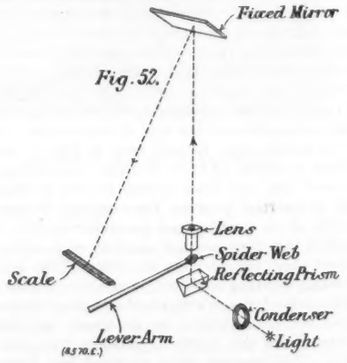


Fig. 52.

with most of its length dipping into a cylinder of water with a well containing mercury at the bottom. The end to be hardened stands out of the water, and is brought into good contact with a graphite block by means of tin foil. This block is in less complete contact with two other graphite blocks, the upper one being used as one electrode of the furnace and the mercury as the other, the electrical circuit passing through the end rod and a steel

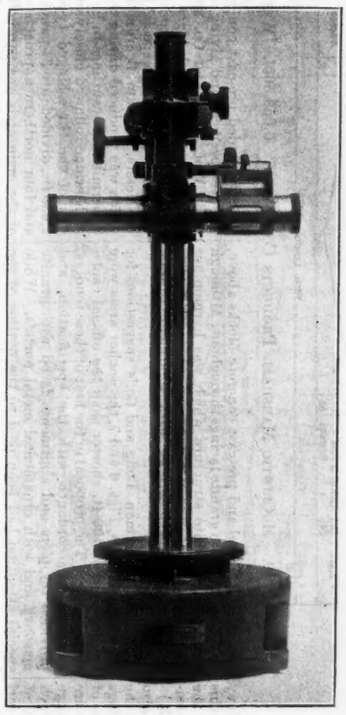
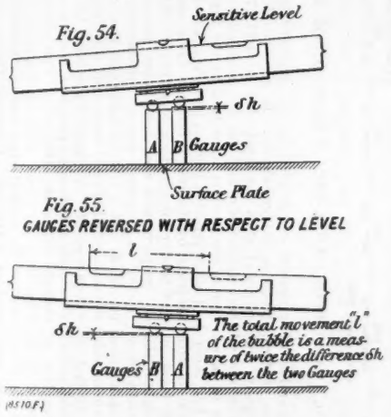


FIG. 53.



FIGS. 53 TO 55. SENSITIVE LEVEL END-GAUGE COMPARATOR.

extension of suitable length into the mercury, and thence back through a copper conductor. The rods are balanced off over a pulley by a weighted cord. When the current is applied, the graphite blocks act as resisters and heat up the top of the end rod till it is desired to quench, when the cord holding the rods is cut and the top of the gauge is quenched and hardened evenly to a depth of about ¼ in., the remainder of the gauge remaining in its normalised, unhardened, and stable condition. The operation takes 700 amperes for one and a-half to two minutes.

For measuring block gauges up to a length of 2 in. to an accuracy of 0·000001 in. the Laboratory has worked out and made the instrument shown in Fig. 49, the magnifying systems of which are shown diagrammatically in Figs. 50 to 52. The block is held by contact with one ball on one face and three balls on the other, giving a four-point contact that avoids the need for the surfaces to be strictly flat or parallel with each other. If the rod by which the three-ball face is adjusted is

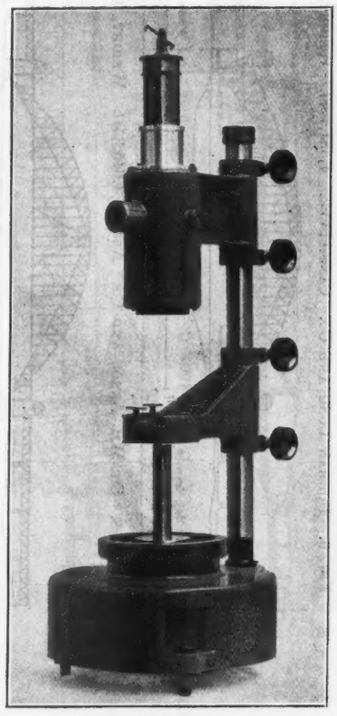
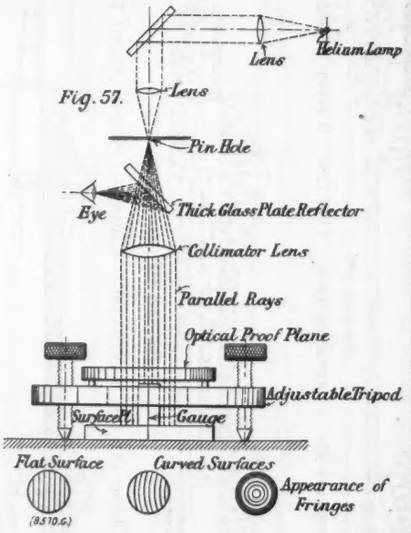


FIG. 56.



FIGS. 56 AND 57. FLATNESS AND PARALLELISM TESTING INSTRUMENT.

set so that the long horizontal lever is at zero when a block of a given length is in position, the substitution of a longer block will distort the steel springs S and displace the lever, which bears a spider's web at its end. By the optical system shown in Fig. 52 the image of the web will thus be displaced on the scale. The magnification is such that a difference of 0·00001 in. produces a displacement on the scale of about 0·3 in.

An alternative apparatus, designed and made at the laboratory, and now being made under patent by the Pitter Gauge and Precision Tool Company, Limited, is shown in Fig. 53, while its principle is illustrated in Figs. 54 and 55. In this instrument the gauges to be compared are wrung upright on an accurately finished surface plate, mounted on a level rotatable table, and a sensitive level with two ball feet rests on them. The reading of the level having been noted, the positions of the gauges are interchanged by rotating the base table, and the level is again read. The total displacement of the bubble measures twice the difference of length between the two gauges.

An apparatus, also designed and made at the Laboratory, for testing the flatness and parallelism of gauge surfaces, is shown in Fig. 56 and its optical system is illustrated in Fig. 57. Here again an accurately finished surface plate is mounted on a level rotatable table, and the gauge to be examined is wrung on to it upright. An optically worked proof plane is then adjusted just above its upper surface, so as to give interference bands in the light from a helium lamp. When viewed through the optical system shown, these bands will appear as straight lines if the surface is accurately flat, but will be curved if it is not. They will be undisturbed when the table is rotated if the faces are parallel, but will show movement if they are not.

THE COMPETITIVE DESIGNS FOR THE SYDNEY HARBOUR BRIDGE.

WE have received from Mr. J. J. C. Bradfield, M.Inst.C.E., Chief Engineer to the Sydney Harbour Bridge, a copy of his report on the tenders submitted for the construction of the bridge which he prepared for presentation to the Under Secretary for Public Works of New South Wales. The specification and plans, issued by the Minister of Public Works and Railways, invited tenders for bridges of the cantilever and arch types in accordance with official designs, but subject to certain variations which were allowed by the specification. The tenderers were not invited to submit independent designs, and although tenders were not solicited for the suspension type of bridge some firms did submit proposals of this character, and these were given careful consideration by the engineer. Six firms made offers for the work, and between them submitted 20 tenders. Messrs. Dorman, Long & Co., of Middlesbrough and Sydney, sent in a total of seven proposals for consideration, the McClintic Marshall Products Company of New York submitted five, the English Electric Company of Australia, Limited, of Sydney, presented three offers, Sir Wm. Arrol and Co. of Glasgow, in conjunction with Messrs. Sir John Wolfe Barry and Partners, sent two offers, as also did the Canadian Bridge Company of Walkerville, Ontario, while the Goninan Bridge Corporation of Newcastle submitted a single proposition. The proposals, as shown both by the illustrations of the designs on pages 130 and 131, and by the summary of tenders in tabular form, are of five general types—arch, cantilever-arch, cantilever, suspension and cantilever-suspension. It may be noted that the so-called "inverted arch" proposals of the McClintic Marshall Products Company and the Canadian Bridge Company are really suspension bridges designed in general conformity with the specification and are so referred to in the figures and the table. The summary given in the table gives the types of the bridges, the amounts of the tenders, the total tonnages of metalwork, the tonnages to be fabricated in New South Wales, the tonnage to be imported, and the country of origin. It should be noted that the weights do not include the gunmetal plates and castings for the portals or the steel rails for the railway tracks.

Messrs. Dorman, Long and Co. had associated with them in the preparation of their proposal, Sir John Burnet and Partners as architects, and Mr. R. Freeman of Sir Douglas Fox and Partners, and Mr. G. Imbault, formerly chief engineer of the Cleveland Bridge and Engineering Company of Darlington, as engineers. In their proposals the firm stated that for the main members of the various structures submitted for consideration they would use silicon steel, while lateral bracings, approach trusses and most of the deck system would be of carbon steel. The first tender referred to as A1 in the table and illustrated in Fig. 1 was for a two-hinged arch bridge of 1,650 ft. span, with essential masonry piers and skewbacks only and did not incorporate the abutment towers shown in the official design. The southern approach spans were made up of five deck spans at 209 ft. centres of

COMPETITIVE DESIGNS FOR THE SYDNEY HARBOUR BRIDGE.

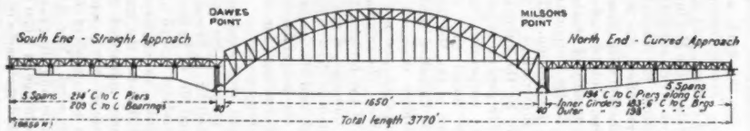

DAWES POINT
MILSONS POINT
South End - Straight Approach
North End - Curved Approach
5 Spans 214' C to C Piers 209' C to C Bearings
1650'
5 Spans
194' C to C Piers along C.L
Inner Girders 183' 6" C to C Brgs
Outer 198'
Total length 3770'

FIG. 1. DORMAN LONG AND CO. ARCH. 3,499,815*l*. WEIGHT, 50,626 TONS.

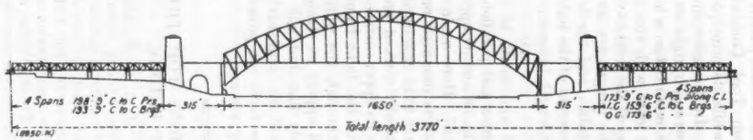


FIG. 2. DORMAN LONG AND CO. ARCH. 4,233,105*l*. WEIGHT, 49,146 TONS.

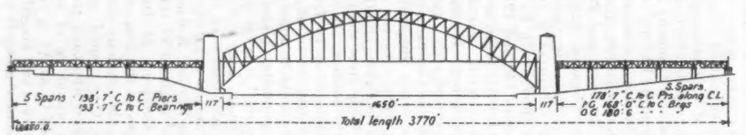

5 Spans 198' 7" C to C Piers 193' 7" C to C Bearings
117'
1650'
117'
5 Spans
178' 7" C to C Prs along C.L
O.C. 168' 6" C to C Brgs
O.C. 180' 6"
Total length 3770'

FIG. 3. DORMAN LONG AND CO. ARCH. 4,217,721*l*. WEIGHT, 50,288 TONS.

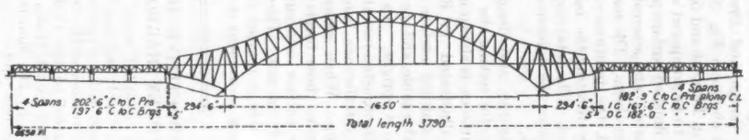

4 Spans 202' 6" C to C Prs 197' 6" C to C Brgs
234' 6"
1650'
234' 6"
4 Spans
182' 9" C to C Prs along C.L
I.C. 157' 6" C to C Brgs
O.C. 182' 0"
Total length 3790'

FIG. 4. DORMAN LONG AND CO. CANTILEVER-ARCH, 3,709,686*l*. WEIGHT, 56,953 TONS.

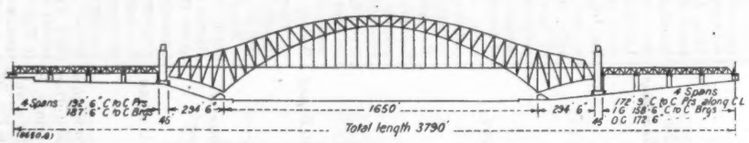

4 Spans 236' 6" C to C Prs 187' 6" C to C Brgs
45'
234' 6"
1650'
234' 6"
45'
4 Spans
172' 9" C to C Prs along C.L
I.C. 158' 6" C to C Brgs
O.C. 172' 6"
Total length 3790'

FIG. 5. DORMAN LONG AND CO. CANTILEVER-ARCH. 3,941,728*l*. WEIGHT, 56,362 TONS.

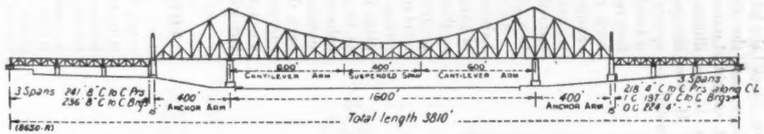

600' CANTILEVER ARM
400' SUSPENDED SPAN
600' CANTILEVER ARM
3 Spans 241' 6" C to C Prs 236' 6" C to C Brgs
400' ANCHOR ARM
1600'
400' ANCHOR ARM
3 Spans
218' 4" C to C Prs along C.L
I.C. 197' 0" C to C Brgs
O.C. 224' 4"
Total length 3810'

FIG. 6. DORMAN LONG AND CO. CANTILEVER. 4,551,758*l*. WEIGHT, 65,453 TONS.

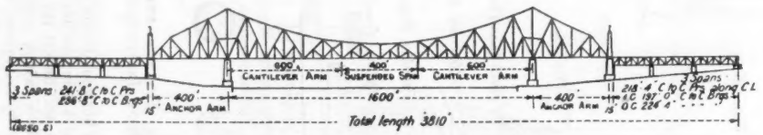

600' CANTILEVER ARM
400' SUSPENDED SPAN
600' CANTILEVER ARM
3 Spans 241' 6" C to C Prs 236' 6" C to C Brgs
400' ANCHOR ARM
1600'
400' ANCHOR ARM
3 Spans
218' 4" C to C Prs along C.L
I.C. 197' 0" C to C Brgs
O.C. 224' 4"
Total length 3810'

FIG. 7. DORMAN LONG AND CO. CANTILEVER. 4,310,812*l*. WEIGHT, 65,303 TONS.

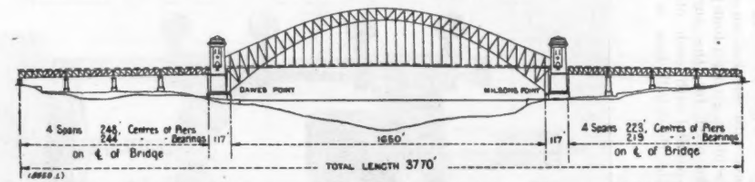


FIG. 8. SIR WM. ARROL AND CO. ARCH. 4,645,351*l*. WEIGHT, 40,228 TONS.

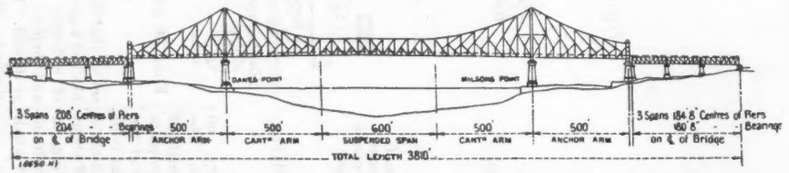


FIG. 9. SIR WM. ARROL AND CO. CANTILEVER, 4,978,488*l*. WEIGHT, 57,653 TONS.

FIG. 10. MCCLINTIC MARSHALL PRODUCTS CO. ARCH. 6,053,565*l*. WEIGHT, 45,854 TONS.

bearings and the northern of a similar number of deck spans but of smaller distance between centres. This bridge was thought simple and elegant, but aesthetically too severe for its setting. The second proposal, see A2 in table and Fig. 2, was in many respects similar to the first suggestion, but had incorporated with it masonry abutment towers faced with pre-cast concrete blocks above the plinth level in place of granite facings. Owing to the design of the abutment towers, which were much longer than those shown in the official design, four steel approach spans of 193 ft. 9 in. were required on the southern side and four similar ones of 166 ft. 6 in. were needed on the northern side. The tendered cost worked out at 4,233,105*l*. This design was thought attractive in appearance, but the abutment towers seemed to be too massive. In their third proposal, A3 in the table, abutment towers faced with granite masonry were proposed as specified by the engineer to the Sydney Harbour Bridge scheme. It was considered that this proposal at a tendered cost of 4,217,721*l*. had the best appearance, and was the most attractive proposition of the tenders submitted by the firm. (Fig. 3.)

Cantilever-arch bridges (see Figs. 4 and 5) were also proposed by the firm of Dorman Long and Co. In the first tender for this type of structure, B1, the facings of the piers and abutments were proposed to be of granite, as specified, but no ornamental towers were provided. At a cost of 3,709,686*l*. this gave a bridge as far as architectural treatment was concerned which was comparable in many ways with the cheapest of the simple arch bridges proposed, but was not, however, thought to be so attractive. The alternative cantilever-arch structure with ornamental towers at the ends of the anchor arms was submitted at a tendered cost of 3,941,728*l*. if granite facings were used up to the plinth level and pre-cast concrete blocks above, or 4,175,523*l*. with granite facings throughout. Although a simple composite structure which was harmonious in conception, it was not regarded as so elegant a bridge as the arch bridge with abutment towers, Fig. 3.

In Messrs. Dorman Long and Co.'s suggestions for cantilever bridges, Figs. 6 and 7, the anchor arms were 400 ft. long, or 100 ft. shorter than the official cantilever bridge. The proposal in the first of these tenders, C1, was in accordance with the specification, and provided for piers and abutments faced with granite masonry and with ornamental metal portals. While special attention had been paid to the outline of the bridge, the appearance was not thought to be as attractive as the two-hinged arch bridge with abutment towers, Fig. 3, while the cost was 334,000*l*. greater. As an alternative the firm submitted proposal C2, which included pre-cast concrete blocks in lieu of the granite specified, and giving a price 240,946*l*. less.

Sir Wm. Arrol and Co. submitted two proposals, arch and cantilever bridges respectively, shown in Figs. 8 and 9. For their construction it was proposed to use for some parts a special high-grade steel supplied by Messrs. William Beardmore and Co., of Glasgow, which was produced during the war for the Admiralty to permit ship-scantlings to be reduced in weight. The arch bridge followed closely on the official design, but was of the three-hinged type with a main span of 1,650 ft., divided into 34 panels, and with four southern and four northern approach spans. The lower chord of the main arch was parabolic, with a rise of 375 ft. to the crown hinge. The arch rib was 60 ft. deep at the crown, 80 ft. deep at the quarter points, and 192 ft. deep at the end posts. The main truss members, lateral-bracing floor girders, outer girders of approach

too massive. In their third proposal, A3 in the table, abutment towers faced with granite masonry were

ends of the anchor arms was submitted at a tendered cost of 3,941,728*l.* if granite facings were used up

ment towers, Fig. 3, while the cost was 334,000*l.* greater. As an alternative the firm submitted proposal C2,

deep at the end posts. The main truss members, lateral-bracing floor girders, outer girders of approach

COMPETITIVE DESIGNS FOR SYDNEY HARBOUR BRIDGE.

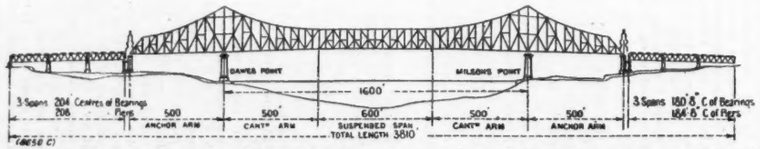


FIG. 11. MCCLINTIC MARSHALL PRODUCTS CO. CANTILEVER. 6,499,377*l.* WEIGHT, 50,283 TONS.

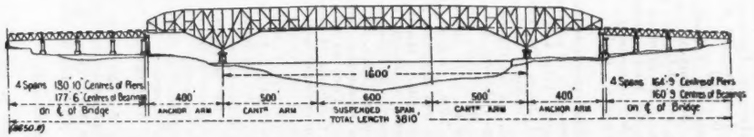


FIG. 12. MCCLINTIC MARSHALL PRODUCTS CO. CANTILEVER. 5,958,356*l.* WEIGHT, 49,115 TONS.

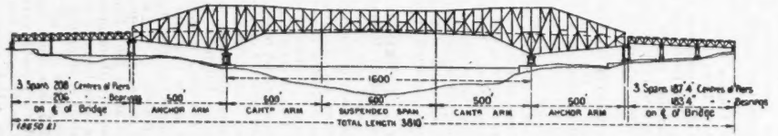


FIG. 13. MCCLINTIC MARSHALL PRODUCTS CO. CANTILEVER. 5,654,531*l.* WEIGHT, 50,191 TONS.

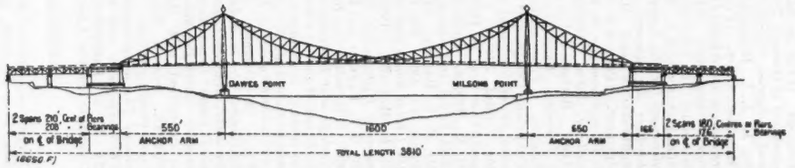


FIG. 14. MCCLINTIC MARSHALL PRODUCTS CO. SUSPENSION. 6,047,547*l.* WEIGHT, 43,059 TONS.

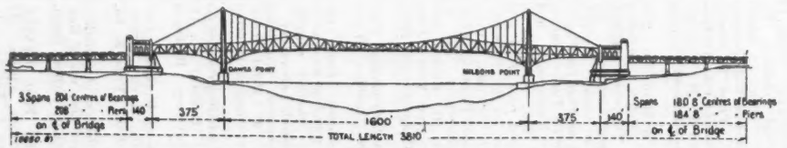


FIG. 15. ENGLISH ELECTRIC CO. OF AUSTRALIA. SUSPENSION. 5,609,125*l.* WEIGHT, 46,108 TONS.

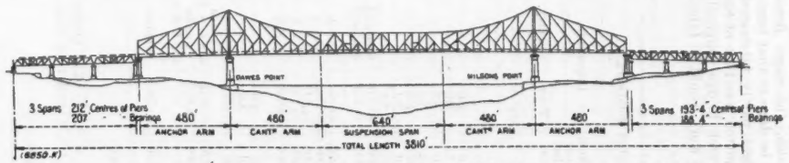


FIG. 16. CANADIAN BRIDGE CO. CANTILEVER. 5,313,404*l.* WEIGHT, 38,064 TONS.

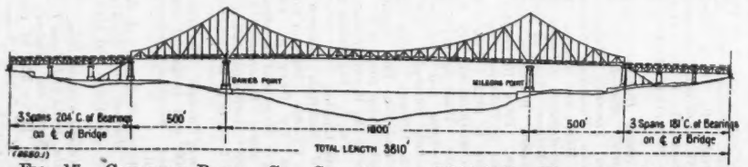


FIG. 17. CANADIAN BRIDGE CO. SUSPENSION. 5,091,202*l.* WEIGHT, 38,015 TONS.

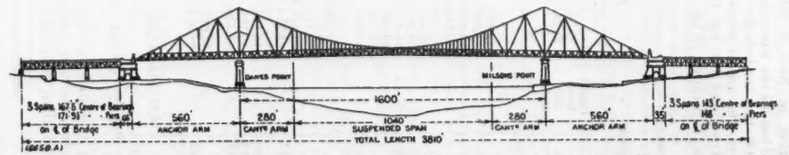


FIG. 18. GONINAN BRIDGE CORPORATION. CANTILEVER SUSPENSION. 10,713,015*l.* WEIGHT, 43,939 TONS.

spans, and main span railway stringers were to be made of the special steel already referred to, but the deck bracing details, and the deck and inner girders of the approach spans would be made of carbon steel. The crown hinges in the arch consisted of 24-in. diameter pins with 36-in. diameter sleeves, while those at the springings were 26 in. in diameter with 38-in. diameter sleeves and were made of forged steel. The tendered price was 4,645,351*l.*

In their cantilever bridge Sir Wm. Arrol and Company followed closely on the official design, except that to allow for simplicity of erection the bracing system suggested was of the "K" type. The main cantilevers were provided with strong sway bracing at the main posts and in the planes of compression verticals and diagonals; these sway frames transferred the load to the lower lateral system, which was formed of K-braced frames. The suspended span was provided with complete sets of upper and lower lateral and portal bracing and intermediate sway bracing. The tendered price in this case was 4,978,488*l.* (Fig. 9). The engineer reported that the special steel proposed by the firm appeared to be quite satisfactory, but the working stresses had been taken as those allowable under the specification for nickel steel, which must have a minimum yield point of 50,000 lb. per square inch, and were too great for the material proposed. The specification provided for the proposed steel gave the minimum ultimate tensile strength as 38 tons (85,120 lb.) per square inch, and the minimum limit of proportionality as 17 tons (38,080 lb.) per square inch.

The McClintic Marshall Products Company submitted five tenders, of which one was for a three-hinged braced-arch type of 1,680 ft. span bearing against abutment towers on either shore. In this (Fig. 10) the rise to the crown hinge was 445 ft. By the use of an ingenious friction clamp in the chord above the crown hinge, the structure was made two-hinged for live loads. This clamp did not come into operation for the relatively slow action of temperature change. The cost, 6,053,565*l.*, was much greater than any of the other arch-bridal proposals submitted.

Three proposals of cantilever bridges were submitted by the same firm, and are illustrated in Figs. 11, 12 and 13. In the first of these, tender C4 in the Table, the outline of the web system in the official cantilever design had been modified, and most of the large compression web diagonals had been reversed in slope, thereby becoming tension members, for which heat-treated carbon steel eyebars would be used. In the second proposal, tender C5, the design was prepared for the purpose of taking every legitimate advantage of the clearance allowed for shipping, the height of the main girders being reduced by 90 ft. Eyebars were again incorporated in the design. The third tender of the firm for this class of bridge was developed from the second proposal which it resembled, the line of development being made for economy in masonry for the anchor and approach piers. Steel bents were substituted for the masonry piers—for the southern approach spans, but those for the northern ones, being on a curve, were retained. These modifications made it possible to make a lower tender, but as was seen from the figures of total costs in the Table the prices exceeded those of any other cantilever bridge, and the appearance in each case was too utilitarian.

A suspension bridge, designed by Mr. Gustav Lindenthal, of New York, was also proposed by the McClintic Marshall Products Company, and is shown in Fig. 14. In this the principal statical element was the braced chain system, and was so arranged that no reversal of stress could occur in the chords of the braced trusses. These chords would be constructed of heat-treated carbon steel eyebars, which Mr. Bradfield suggested was doubtful practice, as there was no guarantee that every individual eyebar received or could withstand its correct stress. The tendered price, 6,047,547*l.*, was the highest submitted for a suspension type of bridge.

The three tenders of the English Electric Company of Australia, Limited, were for a stiffened suspension bridge, the principal one being D2, which incorporated granite-faced piers and abutments. In the second case, D3, these were replaced by concrete facings, while in the third, D4, brick-faced piers and abutments with granite quoins were suggested. The steel structure, see Fig. 15, was the same in each case. This bridge was designed by Messrs. Robinson and Steinman, of New York, who provided a scheme in which the stiffening trusses took the form of continuous girders on four supports, the trusses having variable depths. By a judicious selection of outline, by combining the main cable of the top chord of the stiffening truss over the central portion of the main span and by increasing the depth of the stiffening truss at the intermediate supports and quarter points, the designers produced a suspension bridge proposal of great rigidity.

In general form the cantilever bridge proposed by the Canadian Bridge Company followed the official design, except that a "K" system of web bracing was adopted as in the Quebec bridge. Ample opportunity was thereby afforded for the use of eyebars in the lower chords and tension diagonals of the suspended span, and on the upper chords of the main cantilevers. The tension diagonals and verticals, which in the Quebec bridge consist of built-up members, were also eyebars. The tender was intermediate between the high American tenders and the compara-

tively low British ones. As an alternative, an inverted-arch bridge, which was really a stiffened eyebar cable suspension bridge, was also submitted for consideration, Figs. 17 and D5 in the Table. The proposed bridge had a three-hinged stiffening truss of novel outline, in that the stiffening truss filled the complete space between the cable and the suspended floor, the top chord of the stiffening truss being coincident with the cable. The cable was continuous from the English Electric Company of Australia offered to obtain as much steel from the Broken Hill Proprietary Company as the firm was able to supply. As regards fabrication in New South Wales, the same firms offered that all the work should be done in that territory. Of the tenders for bridges partly fabricated elsewhere, the lowest price submitted was that of Sir Wm. Arrol and Co. for their arch bridge proposal. For this, two-thirds of the steel work would be fabri-

SUMMARY OF TENDERS.

Firm.	Type of Bridge and Amount of Tender.					Fabricated Metalwork.			
	Arch.	Cantilever Arch.	Cantilever.	Suspension.	Cantilever Suspension.	Total Tons.	In New South Wales. Tons.	Imported. Tons.	Imported. Country.
	£	£	£	£	£				
Mr. J. J. C. Bradfield's Estimates	4,339,530	—	—	—	—	*46,600	—	—	—
	—	—	4,704,840	—	—	†61,000	—	—	—
Dorman Long and Co., A.1 ..	3,499,815	—	—	—	—	50,626	All	Nil	—
do. A.2 ..	4,233,105	—	—	—	—	49,146	All	Nil	—
do. A.3 ..	4,217,721	—	—	—	—	50,288	All	Nil	—
do. B.1 ..	—	3,709,686	—	—	—	56,953	All	Nil	—
do. B.2 ..	—	3,941,728	—	—	—	56,362	All	Nil	—
do. C.1 ..	—	—	4,551,758	—	—	65,453	All	Nil	—
do. C.2 ..	—	—	4,310,812	—	—	65,303	All	Nil	—
Sir Wm. Arrol and Co., A.4 ..	4,645,351	—	—	—	—	40,228	13,682	26,546	Scotland.
do. C.3 ..	—	—	4,978,488	—	—	57,653	13,495	44,158	Scotland.
McClintic Marshall Products Company, A.5 ..	6,053,565	—	—	—	—	45,854	12,000	33,854	U.S.A.
do. C.4 ..	—	—	6,499,377	—	—	50,283	13,000	37,283	U.S.A.
do. C.5 ..	—	—	5,958,356	—	—	49,115	15,000	34,115	U.S.A.
do. C.6 ..	—	—	5,654,531	—	—	50,191	17,000	33,191	U.S.A.
do. D.1 ..	—	—	—	6,047,547	—	43,059	15,000	28,059	U.S.A.
English Electric Company of Australia, D.2 ..	—	—	—	5,609,125	—	46,108	All	Nil	—
do. D.3 ..	—	—	—	4,943,763	—	46,108	All	Nil	—
do. D.4 ..	—	—	—	5,109,333	—	46,108	All	Nil	—
Canadian Bridge Company, C.7 ..	—	—	5,313,404	—	—	38,064	4,230	33,834	Canada and U.S.A.
do. D.5 ..	—	—	—	5,091,202	—	38,015	5,400	32,615	Canada and U.S.A.
Goninan Bridge Corporation, E ..	—	—	—	—	10,712,015	43,939	24,236	19,703	Belgium.

* Nickel steel 36·7 per cent. of tonnage. † Nickel steel 28·3 per cent. of tonnage.

anchorage to anchorage, but the main span stiffening truss was hinged at the centre of the span and at the main pier, while the side span trusses were supported on main piers and on end approach piers which took the place of the anchor pier of a cantilever bridge. The design was unique in using a trussed floor girder with simple triangular bracings and verticals, pin connected to the main trusses. This bridge was designed by Mr. C. G. Emil Larsson, of the American Bridge Company. The tendered cost was 5,091,202*l.*, lower than the other two principal proposals for the same type.

The Goninan Bridge Corporation, Limited, proposed a bridge of the cantilever-suspension type, in which the central span was a straight wire cable stiffened suspension bridge, the cables of which were connected directly to the top chords of the cantilever arms. These took the tension from the cables and transferred the loads to the main piers and anchorages. On the cantilever arms subsidiary trusses took the loading from the floor system and transferred it to the lower panel points of the cantilevers. The stiffened truss of the suspended span formed a continuation of the subsidiary truss system. This type of bridge (Fig. 18) was originated by the Strauss Bascule Bridge Company, of Chicago, but no example had yet been built. The price proposed was the highest submitted.

In deciding which was the most acceptable tender the engineer decided that to fulfil the conditions of unquestionable strength and stability, maximum vertical rigidity under rolling loads and lateral rigidity under wind pressures, the arch bridge best fulfilled the conditions and the cantilever type came next. Although both the suspension bridge and the cantilever type were easier of erection than an arch bridge, it was thought that the proposal of the arch type was warranted on the score of the experience in this class of erection of the engineers associated with Messrs. Dorman, Long and Co., and the proposals for erection they submitted, as well as Sir Wm. Arroll and Co. The two-hinged arch bridge met all railway requirements better than any of the other proposals. As far as appearance was concerned the suspension bridge of the McClintic Marshall Products Company the cantilever bridges of Sir Wm. Arrol and Co., and the Canadian Bridge Company, and the arch bridges of Messrs. Dorman, Long and Co. and Sir Wm. Arrol and Co. were picked out as the most handsome structures. Making every allowance for appearance, the arch bridge was selected, and engineering considerations made it appear that the tender of Messrs. Dorman, Long and Co. for the arch bridge, Fig. 3, on page 130, and A3 in the table of tenders was the most acceptable.

It was a condition of tendering that materials suitable for use on the bridge, which were manufactured in New South Wales should be used as far as practicable. In this respect Messrs. Dorman, Long and Co. and cated in Scotland, but the price was 427,629*l.* higher than Messrs. Dorman, Long and Co.'s tender for complete Australian fabrication.

BOOKS RECEIVED.

United States Bureau of Standards. Technologic Papers, No. 246. *Wet-Process Enamels for Cast Iron.* By R. R. DANIELSON and H. P. REINECKER. [Price 10 cents.] No. 247. *A New Electrical Telemeter.* By B. MCCALLUM and O. S. PETERS. [Price 15 cents.] No. 248. *Exposure Tests on Colourless Waterproofing Materials.* By D. N. KESSLER. [Price 15 cents.] No. 249. *Thermal Conductivity Method for the Analysis of Gases.* By P. E. PALMER and E. R. WEAVER. [Price 20 cents.] Washington: Government Printing Office.

United States Bureau of Mines. Bulletin No. 212. *Analytical Methods for certain Metals, including Cerium, Thorium, Molybdenum, Tungsten, Radium, Uranium, Vanadium, Titanium and Zirconium.* By R. B. Moore and others. [Price 40 cents.] No. 223. *An Investigation of Powdered Coal as Fuel for Power-Plant Boilers. Tests at Oneida Street Power Station, Milwaukee, Wisconsin.* By H. KREISINGER and OTHERS. [Price 15 cents.] No. 230. *Analyses of Samples of Delivered Coal. Collected from July 1 to January 1, 1922. With a Chapter on the Tidewater Pool Classifications* By NED H. SNYDER. [Price 20 cents.. Washington: Government Printing Office.

The Principles and Practice of Surveying. Vol. I. Elementary Surveying. By CHAS. B. BREED and GEO. L. HOSMER. Fifth edition. New York: John Wiley and Sons Inc. London: Chapman and Hall, Limited. Price 20*s.* net.]

The Door to the World Markets. An International Year Book. Vol. I. The British Empire. London: World Markets, Limited.

Structural Materials Research Laboratory. Lewis Institute, Chicago. Bulletin No. 6. *Effect of Storage on Cement.* By DUFF A. ABRAMS. Second edition. Chicago: Structural Materials Research Laboratory.

United States Department of Commerce. Simplified Practice Recommendation No. 3. *Metal Lath.* [Price 5 cents.] Washington: Government Printing Office.

Dominion of Canada. The Honorary Advisory Council for Scientific and Industrial Research. Bulletin No. 11. *Nitrogen Fixation.* Ottawa: Advisory Research Council.

Constructional Steelwork. A Manual of Workshop Processes, Methods and Machines. By HARRY ATKIN. London: Chapman and Hall, Limited. [Price 9*s.* 6*d.* net.]

Gas Engineer's Compendium. A Collection of Statistics, Formulæ, Rules and Data for the everyday use of Gas-works Officials and Students. London: Ernest Benn, Limited. [Price 32*s.* 6*d.* net.]

Textbook of Cellulose Chemistry. By EMIL HENSER. Translated from the second German edition. By CLARENCE J. WEST and GUSTAVE J. ESSELEN, JR. London: McGraw-Hill Publishing Company, Limited. [Price 12*s.* 6*d.* net.]

The Aims and Future of the Ramsay Memorial Laboratory of Chemical Engineering. By E. C. WILLIAMS, M.Sc.F.I.C. London: University of London Press, Limited. [Price 1*s.* 6*d.* net.]

Department of Overseas Trade. Report on the Commercial and Industrial Situation in Hungary, February, 1924. By R. J. E. HUMPHREYS. London: His Majesty's Stationery Office. [Price 1*s.* 6*d.* net.]

Forschung und Werkstatt II. Ersatzstoffe. I. Untersuchung von Ersatzriemen. By G. SCHLESINGER and M. KURREIN. 2. *Untersuchung von Bohrölen.* By G. SCHLESINGER and E. SIMON. 3. *Kupferarme Zinklegierungen für die Lagerungen der Werkzeugmaschinen, Einfluss der Giessart und der Schmierung.* By G. SCHLESINGER and M. KURREIN. Berlin: Julius Springer. [Price 0.60 dol.]

Die Dampflokomotive in Entwicklungsgeschichtlicher Darstellung Ihres Gesamtaufbaues. By PROFESSOR J. JAHN. Berlin: Julius Springer. [Price 4.30 dol.]

Ore Dressing. Principles and Practice. By THEODORE SIMONS. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 17*s.* 6*d.* net.]

United States Geological Survey. Mineral Resources of the United States. I: 25. *Manganese and Manganiferous Ores in* 1922. By H. A. C. JENISON and H. M. MEYER. Bulletin No. 750B. *Origin of Certain Rich Silver Ores near Chloride and Kingman, Arizona.* By E. S. BASTON. [Price 5 cents.] Water Supply Paper No. 489. *The Occurrence of Ground Water in the United States with a Discussion of Principles.* By O. E. MEINZER. [Price 60 cents.] No. 492. *Summary of Hydrometric Data in Washington,* 1878-1919. By G. L. PARKER and L. LEE. [Price 40 cents]. No. 497. *The Salton Sea Region, California, A Geographic, Geologic and Hydrologic Reconnaissance, with a Guide to Desert Watering Places.* By J. S. BROWN. [Price 50 cents.] Washington: Government Printing Office.

Traité de Stabilité du Matériel des Chemin de fer. Influence des Divers Eléments de la Voie. By GEORGES MARIN. Paris: Ch. Beranger. [Price 58 francs net.]

Bibliographie de la Relativité. By MAURICE LECAT. Brussels: Maurice Lamertin. [Price 90 francs.]

United States Department of Commerce. Lighthouse Service. *Radio Fog Signals and their Use in Navigation in connection with the Radiocompass.* By G. R. PUTNAM. Second Edition. Washington: Government Printing Office.

Chemical Thermodynamics. An Introduction to General Thermodynamics and its Applications to Chemistry. By J. R. PARTINGTON, M.B.E., D.Sc.. London: Constable and Co., Limited. [Price 10*s.* 6*d.* net.]

CONTRACTS.—Messrs. Holt and Willetts, of Cradley Heath, have received an order for nineteen 15-ton overhead travelling cranes from the South Eastern Construction and Power Company, Limited, in connection with the Southern Railway Electrification.

THE NORTHAMPTON POLYTECHNIC INSTITUTE.—The vacant Principalship of the Northampton Polytechnic Institute, Clerkenwell, caused by the death of Dr. R. Mullineux Walmsley, has been filled, subject to approval of the London County Council, by the appointment of Mr. S. C. Laws, M.A., M.Sc., who has been Principal of the Wigan Mining and Technical College for the last nine years. Mr. Laws was educated at University College, Nottingham, and St. John's College, Cambridge, where he was an 1851 Research Scholar and worked in the Cavendish Laboratory under Sir J. J. Thomson.

THE GARVEL GRAVING DOCK, GREENOCK.—At a special meeting on the 16th inst. the Greenock Harbour Trust agreed to proceed with a scheme for the extension of the Garvel Graving Dock. Schedules are to be prepared and issued to contractors as soon as practicable. The proposal is to widen the dock to 65 ft. and deepen it to the extent of 4 ft., at a cost of 67,000*l.* When completed the graving dock will be capable of dealing with vessels of 16,000 tons. Messrs. Lithgow's, Limited, of Port Glasgow, have offered 25,000*l.* towards the cost of the scheme, and a contribution of 11,000*l.* will be made by the Government Unemployment Grants Committee if the work is started at once.

THE JULY "SKANDINAVISKA KREDITAKTIE-BOLAGET."—This quarterly Report on Scandinavian business, the third issued this year, is chiefly notable on account of the summary of the balance sheets of numerous Swedish companies for the years 1919–23, and the article by Professor Gustav Cassel on the "Stability of the Gold Standard" contained in it. The summary was undertaken to elucidate the fact that most of the Swedish companies whose reports for 1923 were published during the first quarter of the present year showed increased profits. The figures show that the average of the percentage dividends on their own capital taken over all companies fell from 7·4 in 1919 to 3·6 in 1922. In 1923, however, it had increased to 4·1 per cent. In his article Professor Cassel points out the fallacy of the supposition that because the United States holds a large portion of the gold in circulation that country would necessarily require to face a new inflation. At present about 200 million dollars could be added to the circulation without necessarily entailing a rise in prices. It was to be borne in mind that an accretion of gold to the extent of 50 million dollars would cause a rise in the level of prices of 1 per cent. The dollar must now be regarded as a much firmer basis for the value of gold than it was possible to conceive two years ago. The way to the restoration of the gold standard now lies open for Europe, which, moreover, has it in her own power by connecting her currencies to gold to contribute still further to the stability of gold.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The market for raw and semi-finished materials reflects the quieter condition of affairs prevailing in the manufacturing branches. Few buyers can be induced to enter into contracts for deliveries far ahead, the general feeling amongst consumers being that, despite the reported unremunerative nature of current iron and steel production, the slump in the demand must be reflected in further price cuts. Foreign competition, judging from the drop in imports of semi-manufactured materials, has suffered a check, though whether this will prove to be merely temporary remains to be seen. Belgian products are still available at 1*l.* 10*s.* to 2*l.* per ton below the local cost of manufacture. There is little sign of increased activity in basic steel output. Many of the local furnaces continue idle, and until more orders are placed with rolling mills, forges and foundries, this condition of things, it is feared, will be unaltered. Recent contracts have shown little, if any, profit, though producers are hoping that the completion of stock-taking operations and the removal of the holiday influence will act as a spur to buying. There is a fair measure of activity in the manufacture of heavy machinery for steel and engineering works equipment, in colliery machinery and appliances, and in automobile steel and fittings. Business with agricultural engineers continues depressed owing to the slump in the export demand, though, considering the restriction in foreign purchases, the output of agricultural castings, cutting parts, taps and dies, is on a fairly robust level. More rustless iron is going into use in the building and constructional trades.

South Yorkshire Coal Trade.—In view of the all-round easing in the demand, and particularly having regard to the fall in Continental purchases, collieries have found it impossible to maintain official quotations on the basis recently fixed. Cuts varying from sixpence to two shillings a ton are announced in industrial fuel, while house-coal, which reflects the seasonal slump, is from 1*s.* 6*d.* to 3*s.* per ton easier. Only slacks and smalls are maintained at their former rates, this being mainly due to the effect of restricted supplies and to the fairly robust demand for washed sorts. Revised quotations:—Best handpicked branch, 32*s.* to 33*s.*; Barnsley best silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 25*s.* to 27*s.*; Derbyshire best house, 23*s.* to 25*s.*; Derbyshire best large nuts, 21*s.* to 25*s.*; Derbyshire best small nuts, 15*s.* to 17*s.* 6*d.*; Yorkshire hards, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

THE LATE MR. GARDNER INGLIS.—The managing director of Messrs. G. Inglis and Co., Limited, Airdrie, Mr. Gardner Inglis, died at his residence, Crindledyke, Airdrie, on Thursday, the 10th inst. He was formerly chief engineer of Messrs. Gibb and Hogg, Limited, Airdrie, and later started the general engineering and boilermaking company which bore his name. He was the designer of the Inglis boiler and founded the Inglis Boiler Syndicate of Glasgow to exploit it. Mr. Inglis was a director of Messrs. A. Shanks and Son, Limited, of Arbroath, and was also chairman of the Scottish Ironfounder's Association.

SENTINEL-CAMMELL STEAM RAIL MOTOR AT THE BRITISH EMPIRE EXHIBITION: ERRATA.—We regret that owing to the use of a contraction the consumption of this coach was stated, on page 7 of our issue of July 4, to be 5 lb. per ton-mile, and the overall costs 6*d.* per ton-mile. The unit should have been "train mile" in both cases.—It is also pointed out that the figure supplied to us of 42 ft. 10 in. as the distance between bogie centres should actually be 39 ft. 4 in., while, with regard to braking, an expanding brake drum is fitted to one wheel of each axle on opposite sides of the bogies, all axles therefore being braked.

MANCHESTER ENGINEERS VISIT DERBY.—On Thursday, the 17th inst., a large party of the Manchester Association of Engineers travelled to Derby to view the London, Midland and Scottish Railway workshops. The visitors made a complete tour of the works and witnessed the various processes of carriage construction. An interesting feature was the complete erection of a corridor carriage in 25 minutes. During the afternoon tea, the President of the Association, Mr. Herbert Bates, proposed a vote of thanks to Mr. R. W. Reid, C.B.E., the Carriage and Wagon Superintendent of the L.M.S. Railway Company, whose courtesy permitted the visit. The former stated that, so far as automatic production of railway vehicles was concerned, they had nothing to learn from the United States, and he paid a high tribute to the workmen and staff for the excellent results achieved. Mr. Lemon, the Works Manager, replied.

THE FARADAY SOCIETY.—The annual general meeting of the above Society was held on July 7, the yearly report indicating considerable activity, as a result of which the accounts showed a deficit of 109*l.* 11*s.* 5*d.* Eleven meetings were held during the past year, four of which were general discussions on the subjects of (1) Alloys Resistant to Corrosion; (2) The Physical Chemistry of the Photographic Process; (3) The Electronic Theory of Valency; (4) Electrode Reactions and Equilibria. The sales of transactions and reprints amounted to nearly 900*l.*, which exceeded the income from subscriptions, the membership being 432. An appeal for new members was made in the annual report. Professor F. G. Donnan, C.B.E., F.R.S., was elected to succeed Sir Robert Robertson as president. Particulars relating to the Society may be had from the Secretary, Mr. F. S. Spiers, 90, Great Russell Street, London, W.C. 1.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The Cleveland pig-iron trade is characterised by extreme quietness, and, at present, there is nothing to indicate early change for the better. Hope, however, is expressed that when buying for autumn needs commences, transactions may be on a better scale than is now promised. Makers' stocks are stated to be well sold, but customers are not taking out their full quantities, and output is in excess of current requirements, so that the statistical situation threatens to become unsatisfactory. Whilst producers are very loath actually to lower quotations, buyers state that they can obtain substantial price concessions when they have definite business to offer. No. 1 is quoted 92*s.* 6*d.*; No. 3 g.m.b., 87*s.*; No. 4 foundry, 86*s.*; and No. 4 forge, 85*s.*

Hematite.—There is very little doing in East Coast hematite. Supply is a good deal more than ample, and prices are weak. Nos. 1, 2, and 3 are offered freely at 95*s.*; and No. 1 is on sale at 95*s.* 6*d.*

Foreign Ore.—Imported ore is almost unsaleable, consumers being well placed as regards supplies and unwilling to pay rates asked. Sellers still base market quotations on best rubio at 23*s.* c.i.f. Tees.

Blast-furnace Coke.—Durham blast-furnace coke is in only very moderate request. Good medium qualities vary from 26*s.* 6*d.* to 27*s.* delivered to users in this district.

Manufactured Iron and Steel.—There are continued inquiries for galvanised corrugated sheets for Japan, South Africa, South America, and Australia, but producers are so full of orders that they are unable to enter into further contracts for delivery much before the end of the year. For 24 gauge descriptions the export price is quite 18*l.* 5*s.* Nearly all other finished iron and steel articles are slow of sale and weak in price. Manufacturers are meeting with keen continental competition in home markets and in districts abroad that used to draw extensive supplies from this locality. Prices for overseas trade are matters of individual negotiation, but for home business sellers still name the following agreed figures:—Common iron bars, 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered) 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.*; and fish plates, 13*l.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Depressed conditions continued in the Welsh coal trade. New business remains insufficient to enable collieries to keep pits working regularly, and there is such a glut of small coal that the working of large is being restricted, because of the fact that wagons are held up under load with small, with the result that in many cases colliery undertakings have not had enough trucks to keep pits working. Exports of coal as cargo last week amounted to only 471,650 tons, compared with 474,000 tons in the previous week, and 612,700 tons a fortnight earlier. Shipments to France were increased from 174,660 tons to 181,920 tons, and to Italy from 61,820 tons to 76,800 tons, but to South America were reduced from 78,400 tons to 74,840 tons, to Spain from 49,270 tons to 31,100 tons, and to Greece from 15,910 tons to 6,730 tons. Exports from Newport were increased from 69,450 tons to 99,420 tons, but at the other ports were reduced, Cardiff's total falling from 277,480 tons to 271,300 tons, Swansea from 60,600 tons to 54,630 tons, Port Talbot from 58,450 tons to 42,950 tons and Llanelly from 8,020 tons to 3,330 tons. "The position of the Welsh coal trade has," states Mr. Finlay A. Gibson, secretary of the South Wales and Monmouthshire Coalowners' Association, "been seriously aggravated by the increase in the cost of production under the new national wages agreement. This peril was discredited by the miners' leaders in the agitation that led to the termination of the old agreement and the arrangement of a new one. They argued that it was practicable to meet the increased cost of production by the raising of the prices to the consumer and by other methods. The fallacy of that argument was again and again exposed, it being pointed out that to attempt to counteract the economic law by artificial means would simply restrict the demand for coal, increase the irregularity of the workmen, and decrease the number of men employed. Every one of these warnings has been justified, and the export trade of the Bristol Channel ports in June was in volume the smallest since that of July, 1922." At the moment, prices generally, are weak on the basis of 28*s.* to 28*s.* 6*d.* for best Admiralty large, 25*s.* to 26*s.* 6*d.* for drys, 23*s.* 6*d.* to 27*s.* for Monmouthshires, and 13*s.* 6*d.* to 17*s.* 6*d.* for smalls.

INDUSTRIAL WELFARE.—The Industrial Welfare Society announces that the lecturers at its fifth annual conference on industrial welfare, which will be held at Balliol College, Oxford, from September 12 to 17, will include the Master of Balliol (Professor Alexander D. Lindsay) and Miss Maude Royden. The subjects to be discussed include education in industry; the ethical bases of welfare, an employer's view of welfare, industrial legislation and the welfare worker, and first-aid and ambulance organisations. Mr. John Lee, author of several books on industrial organisation, will lecture on "Discipline or freedom—an Industrial Problem."

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—A dull tone has recently come over the general trade of the country, and the majority of industries are experiencing a spell of quietness. The Glasgow Fair holidays coincide this year with those of Edinburgh and Aberdeen, so that the three chief cities in Scotland are this week on holiday. The net result is that there is very little business doing at present. The shipbuilding yards and engineering works on the lower reaches of the Clyde are all again in operation and quite a fair amount of activity is general, the shipyards in the Greenock and Port Glasgow area being fairly well off for work. The state of trade throughout the country during the first half of the year has only been moderate overall, and some industries have had a very poor time. For the second period of the year the prospects are not very encouraging, but all are hoping that a revival in trade may set in. Such would be very welcome in the pig-iron trade, where there is every likelihood of another four of the blast furnaces recently in operation being blown out meantime.

Scottish Steel Trade.—With the steel works in the West of Scotland all off for the annual holidays, there is no business this week. A restart will be made next Monday, but one or two establishments will not re-open until Monday, August 4. That will give specifications the chance of accumulating. The closing down for the holidays was very quiet, as little stir for deliveries took place. This week a fair inquiry is reported, but little in the way of fresh business has been secured, and unless the next few days brings something forth the outlook for the restart is not very hopeful. Foreign inquiries are fair, but buyers are not placing many contracts, except for black and galvanised sheets, the makers of which are booked well on towards the end of the year. Prices keep steady and are as follow:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{1}{4}$ in. to $\frac{1}{2}$ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—In the Scottish malleable iron trade a distinct quietness has been general for some months back, and order books are very poor. Broken time has been all too general and inquiries this week do not show much sign of improving. Not only has bar iron been in poor demand, but the re-rolled steel branches seem also to be experiencing similar conditions. Quotations are unchanged, "Crown" bars being quoted at 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—In the Scottish pig-iron trade the re-lighting of furnaces is in most cases to be delayed beyond the usual holiday period, in the hope that an improvement in demand will be forthcoming. Up to the present, however, there has been little sign of that, and the stocks which have recently been accumulating would seem to be quite equal to the demands of the next few weeks. Prices again show an easier tendency and are quoted to-day as under:—Hematite, 5*l.* per ton, delivered at the steel works; foundry iron No. 1, 5*l.* per ton, and No. 3, 4*l.* 15*s.* per ton, both on trucks at makers' yards.

CAST-IRON RESEARCH ASSOCIATION.—The Bulletin for June issued by this Association has just come to hand. It contains interesting figures on rustless cast-iron, including English non-corrosive iron, the American Duriron and Corrosiron, and a brand made by a Swiss firm. The Bulletin also gives abstracts from foundry literature. The Council has decided that the Bulletin is to be published regularly each quarter.

THE CUNARD LINE.—As a souvenir of the British Empire Exhibition, the Cunard Line have issued an attractive and artistic brochure, with the title "Eight Decades of Progress," outlining the progress in ship construction, as instanced in the vessels of the company built from 1840 to the present day. The story of the great commercial adventure started by Mr. Samuel Cunard, which was destined to be such a significant factor in the improvement of trade and the goodwill of nations, is ably told by Mr. E. Keble Chatterton, while the illustrations, in line and colour, prepared from original works by Messrs. T. J. Bond and C. E. Turner, add greatly to the value of a most exceptional publication.

IRON AND STEEL INSTITUTE.—The autumn meeting of the Institute will be held at the British Empire Exhibition, Wembley, on Thursday and Friday, September 4 and 5, at 10.30 a.m. each day. The following is a list of the papers that have been offered for discussion at the meeting:—(1) L. Aitchison and G. R. Woodvine, "Changes of Volume of Steels during Heat Treatment"; (2) C. Benedicks and V. Christiansen, "Investigations on the Herbert Pendulum Hardness Tester"; (3) E. D. Campbell and G. W. Whitney, "The Effect of Changes in Total Carbon and in the Condition of Carbides on the Specific Resistance and on Some Magnetic Properties of Steel"; (4) C. A. Edwards, "Pickling: The Action of Acid on Iron and Steel, and the Diffusion of Hydrogen through the Metal"; (5) J. Newton Friend and W. E. Thorneycroft, "Examination of Iron from Konarak"; (6) M. A. Grossman and E. C. Bain, "On the Nature of High-speed Steel; (7) Axel Hultgren, "Improvements in the Brinell Test on Hardened Steel, including a New Method of Producing Hard Steel Balls"; (8) W. Rosenhain, "Present Position of the Theories of the Hardening of Steel"; (9) F. C. Thompson and W. E. W. Millington, "The Effect of Free Surfaces on the Plastic Deformation of Certain Metals."

OXYGEN JET CUTTING MACHINE.

CONSTRUCTED BY THE GODFREY ENGINEERING WORKS, WOOD GREEN, LONDON.

(*For Description, see Page* 124.)

FIG. 10. LARGE MACHINE WITH TRAVELLING CARRIAGE.

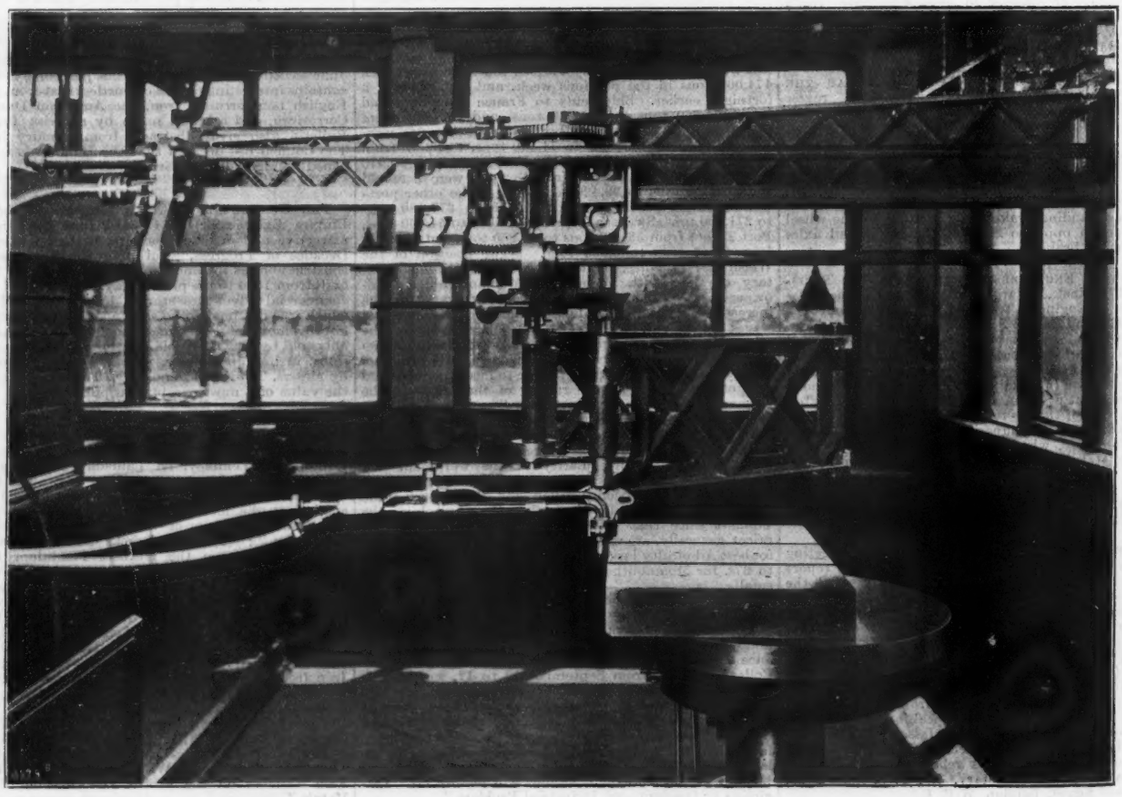


FIG. 11. ENLARGED VIEW SHOWING BEAM, GEARING AND HINGED FRAME.

14,000 B.H.P. TURBINES; DEER LAKE POWER STATION, NEWFOUNDLAND.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, ELSWICK.

(*For Description, see Page* 125.)

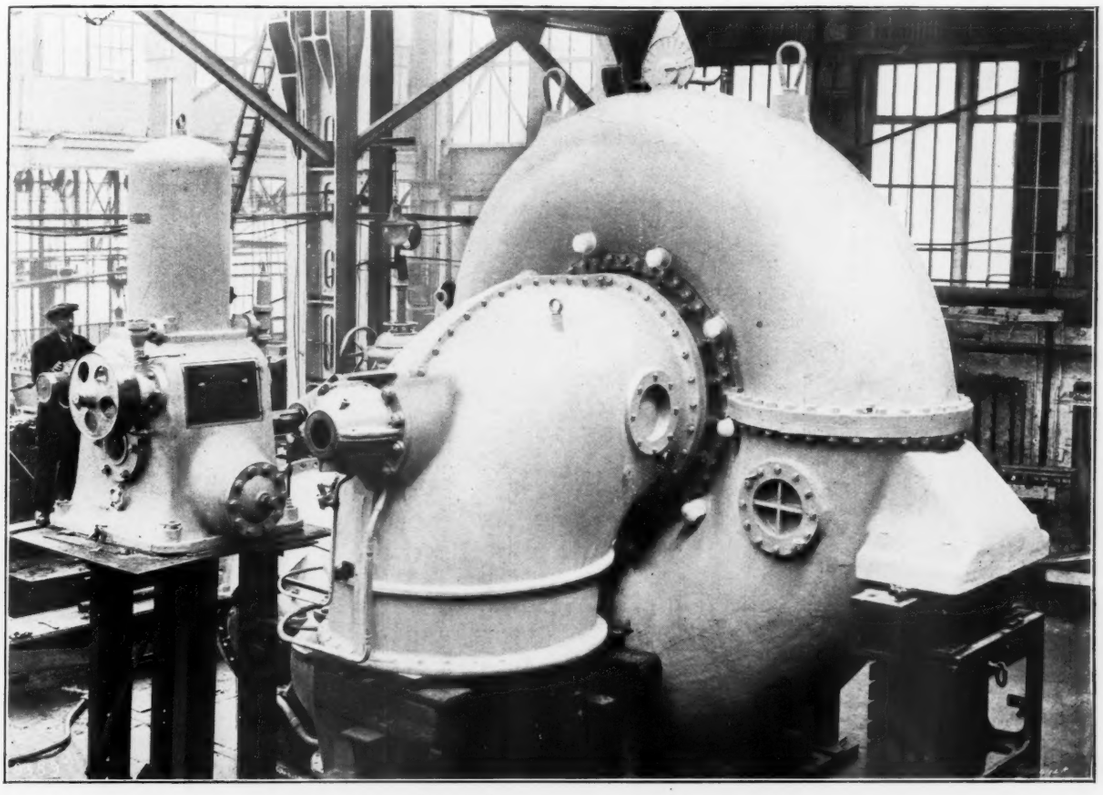


FIG. 2. VIEW SHOWING DISCHARGE BEND AND GOVERNOR.

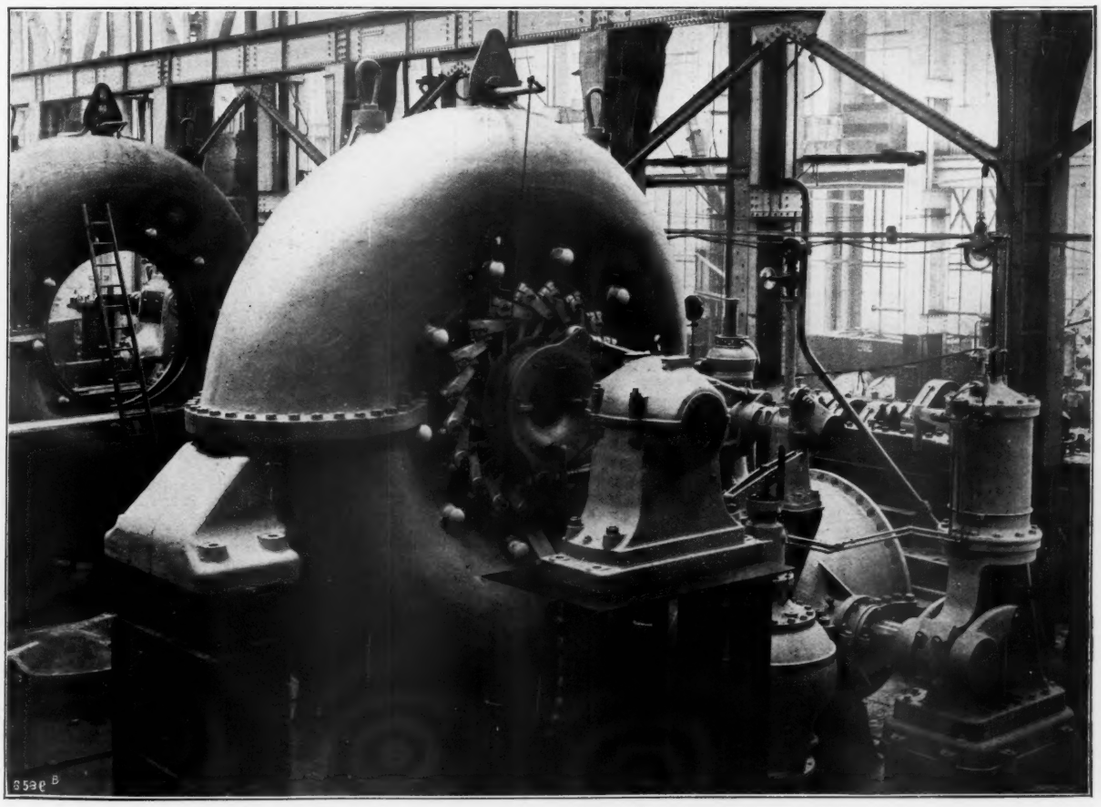


FIG. 3. VIEW SHOWING GUIDE VANE CONTROL GEAR.

(*To face page* 126.)

HUMBER RIVER DEVELOPMENT SCHEME OF THE NEWFOUNDLAND POWER AND PAPER CO., LTD.

MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, CONTRACTORS.

(*For Description, see Page* 125.)

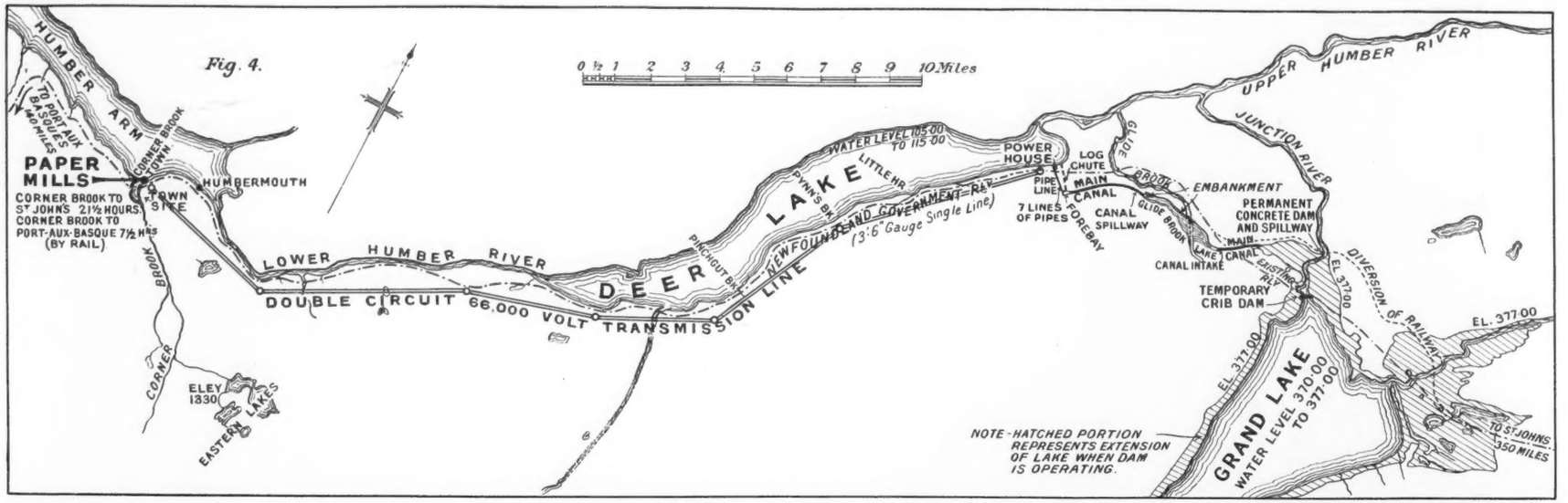


FIG. 4. MAP SHOWING THE DEVELOPMENT SCHEME.

FIG. 5. GENERAL VIEW OF CORNER BROOK, SHOWING SITE OF PAPER MILLS.

Fig. 5. General View of Corner Brook, Showing Site of Paper Mills.

HUMBER RIVER DEVELOPMENT SCHEME OF THE NEWFOUNDLAND POWER AND PAPER CO., LTD.

MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, CONTRACTORS.

(*For Description, see Page* 125.)

Fig. 6. Down-Stream End of Eastern Section of Canal.

Fig. 7. The Large Fill at Glide Brook Depression.

Fig. 8. View of Dam at End of Season of 1923.

Fig. 9. View of Dam in Spring of 1924.

ELECTRICAL GEAR FOR THE HUMBER RIVER DEVELOPMENT SCHEME, NEWFOUNDLAND.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 125.)

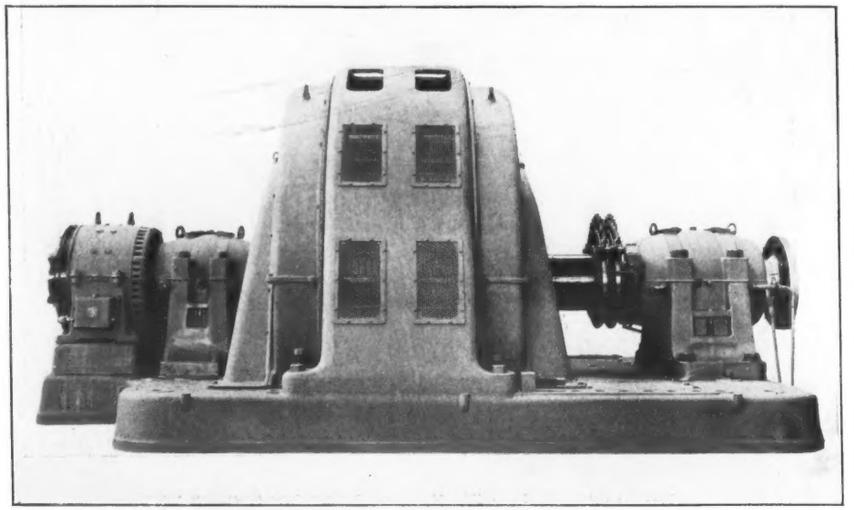


FIG. 10. 10,250-K.V.-A. 6,000-VOLT ALTERNATOR WITH EXCITER.

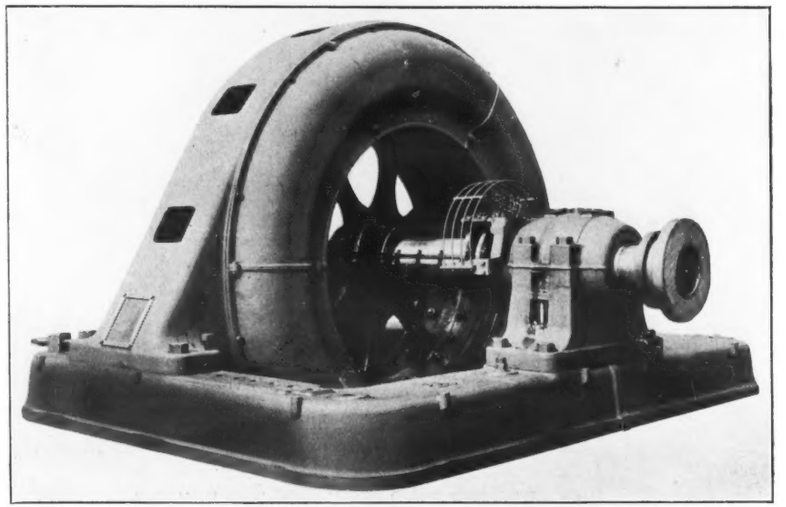


FIG. 11. 2,600-H.P. SYNCHRONOUS MOTOR FOR PULP GRINDER.

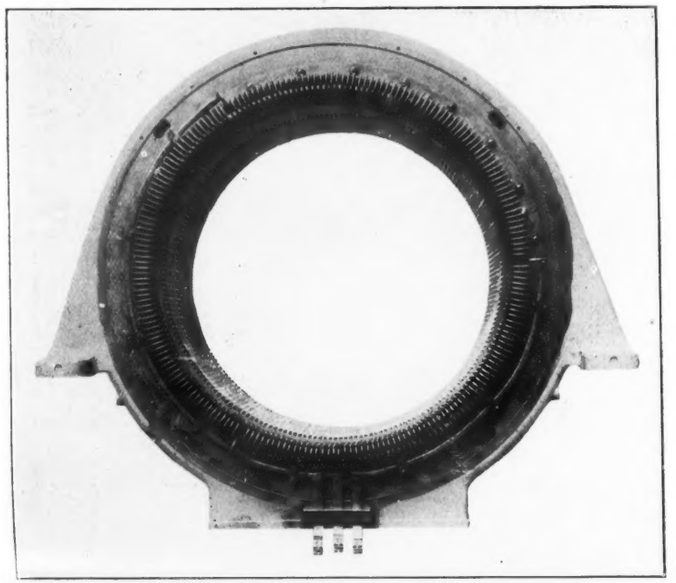


FIG. 12. STATOR OF 10,250 K.V.-A. ALTERNATOR.

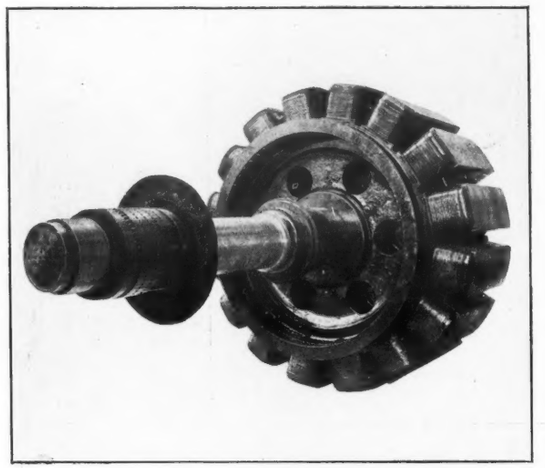


FIG. 13. ROTOR OF 10,250 K.V.-A. ALTERNATOR.

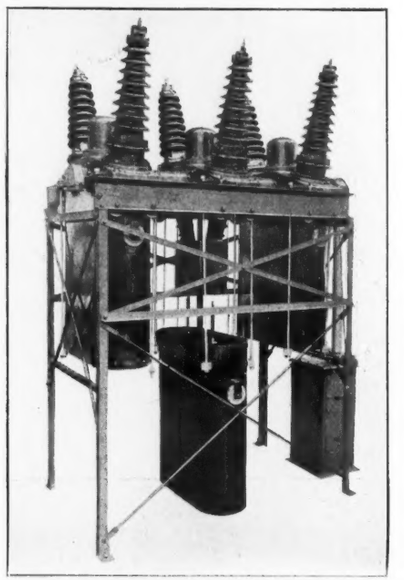


FIG. 14. 66,000-VOLT OIL CIRCUIT-BREAKER.

(*To face page* 127.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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ENGINEERING.

FRIDAY, JULY 25, 1924.

THE TRAINING OF ENGINEERING TEACHERS.

IN training teachers for the elementary schools, considerable attention is devoted to method, as distinct from a knowledge of the subject being taught. Such questions as the maintenance of discipline, the acquirement of the confidence of the class, and the best form of presentation of the subject receive careful consideration, and, as a result, enormous progress has been made in recent years in the technique of teaching in such schools. Stereotyped methods have to a large extent been abandoned, and in their place methods which tend to develop the individual capacity of each student have been substituted. The advantage to the pupil of these changes is rarely disputed, but it appears to be generally assumed that such advantages would disappear if the same methods were applied in higher education. This is hardly the place to enter into a discussion of the methods of teaching adopted in our secondary schools, except in so far as they affect students who afterwards follow an engineering course, but the work of such students, particularly in mathematics, tends to show that their preparation is defective. It should be possible for the great majority of boys in secondary schools to reach the matriculation standard before they leave, and if this standard were attained, there would be no reason for criticism.

We are more concerned with technical education, whether in the university or evening class, and an examination of the methods of teaching adopted in the great majority of cases shows that they are purely haphazard. No recognised course of preparation exists for teachers who propose to take up this branch of the profession, and as a result, each teacher develops his own individual methods. Technical teachers are, in the main, recruited from the ranks of university graduates, whose only knowledge of the technique of teaching is derived from an unconscious study of the methods of the university staff; and, as a result, they take up their duties with practically no qualifications beyond a knowledge of the subject that they are called upon to teach. The methods of presentation adopted in the university are frequently quite unsuitable for more elementary students, and it is therefore not unlikely that the teacher will commence with a bias in the wrong direction. Apart from university graduates, a number of part-time teachers in evening schools are recruited from the staffs of various commercial concerns throughout the country, and although such men will be probably better qualified to gain the interest of their classes and to maintain discipline, by reason of their more mature age and their greater knowledge of men, they are equally ignorant of the best methods of subject presentation. In either case the result must be unsatisfactory, and the waste of effort deplorable in the aggregate. It may be said that the beginner in every profession must be largely ignorant of his duties, and that certain types of knowledge can only be gained by actual experience. In most vocations the novice commences his duties under the strict eye of a superior, and his errors of inexperience are immediately pointed out to him and corrected. In this respect the technical teacher is in a peculiar position. He may be given a hasty introduction to his class by his principal, or, more frequently, is left to make his own introductions, and he then finds himself in an entirely isolated position, and is left week by week to obtain control of his class and to interest them in his subject by a process of trial and error. Possibly two or three times in each term he may be visited by his principal or by one of His Majesty's inspectors, but such visits are hardly occasions on which his difficulties are likely to be discussed in a sympathetic spirit, and in the main, he is left to make his own way as best he can. It is most unusual for a principal actually to attend any of the lectures of his teaching staff, and many of the latter would regard it as a breach of etiquette for him to do so. This appears to be quite a mistaken attitude, as it is quite impossible for the principal to enter into his assistant's difficulties effectively unless he has seen them at first hand. Generally there is far too little collaboration and discussion between the head and his staff, and it is the duty of the former to make opportunities for a more frequent interchange of views. If a man is left entirely isolated and is observant and adaptable, he will, in course of time, evolve a working system which will serve its purpose, but it would be absurd to maintain that a system arrived at by such means was the best possible, and, in any case, the teacher has learnt his lesson at the expense of the student.

Two remedies seem to be called for, first, a course of training in method, and secondly, an opportunity for the interchange of ideas with other teachers.

In the absence of recognised training colleges for technical teachers, it appears essential that every teacher should be called upon to pass an examination in method, and that classes in this subject should be held both in the university and the evening school. The result would probably be a temporary shortage of teachers, in so much as it would eliminate those who take up teaching merely as a stop-gap until such times as they are able to obtain other employment. Although it is true that such men occasionally remain in the profession and make excellent teachers, yet on the other hand they are generally unsatisfactory, and little more than temporary inconvenience would result from their elimination.

Such a regulation would not affect those already in the profession, although it would not be unreasonable to insist, as was done in the case of elementary school teachers under somewhat similar circumstances, that all existing teachers should qualify themselves within a certain time. Such a method could not be altogether satisfactory, as there are a number of men now engaged in teaching who are too old to change their methods, and who at the best would give no more than lip service to the new regulations, and would in all probability exert strenuous opposition to any such measure of reform.

In the case of those now engaged in teaching, an extended opportunity for the exchange of ideas

FIG. 14. 66,000-VOLT OIL CIRCUIT-BREAKER.

FIG. 13. ROTOR OF 10,250 K.V.-A. ALTERNATOR.

FIG. 12. STATOR OF 10,250 K.V.-A. ALTERNATOR.

offers a much wider hope of improvement. The position of isolation in which technical teachers stand has already been referred to, but it is not generally realised how entire this isolation is. The teacher is a member of a small staff of a college or university, and it is quite probable that he is the only man on that staff who has a specific knowledge of his particular subjects. By an unfortunate perversion of human intelligence, he is debarred from the discussion of his profession outside working hours, on the grounds that talking shop is bad form. His colleagues will be prepared to discuss gold *ad infinitum*, but any attempt to introduce the subject of their life work will be met with marked disapproval. This attitude is not peculiar to the teaching profession, but whereas the members of most professions recognise the necessity for an institution in which their peculiar problems can be adequately discussed in their leisure time, the teaching profession stands in this respect in a position of peculiar isolation. It is true that there are several associations of teachers for various purposes, but a discussion of the problems which arise in the course of their profession is not one of these. Again we have a striking exception in the case of elementary school teachers, who would appear to be the only teachers who take their profession seriously. It is difficult to know whether to class the isolation of the average technical teacher as tragedy or comedy, but we incline to the former when we see colleagues in the same institution using different systems of units and each condemning to their students those made use of by the others. Perhaps an even more striking instance is the detachment of the mathematical teacher, whose course of instruction has usually little bearing on the needs of engineering students.

We hesitate to suggest the formation of still another institution, and probably it is not necessary. The art of teaching is a subject of interest to every engineer, and the difficulty would be met to a great extent if the councils of the larger engineering institutions would encourage the reading of papers on the subject. Occasional papers have already been read on the training of engineers, which forms a pertinent introduction to the subject. As there is an increasing tendency for the institutions to decentralise, and to have the same paper read in a number of widely distributed centres throughout the country, the majority of teachers would have an opportunity of taking part in the discussions, and what would probably be of greater value, the one-time student who had had the opportunity of putting his knowledge to the test of practical application, would be able to express his views on his own technical education. As a result of this, the teacher would be to some extent familiarised with current works practice, and the student would derive immediate benefit in those subjects which bear more immediately on his future work in industry, such as machine drawing and design.

THE WAR OFFICE SPECIFICATION FOR SUBSIDY LIGHT LORRIES.

ONE of the lessons of the war is that the standing army can only be regarded as a nucleus capable of rapid expansion, and, in view of the vital place taken by motor transport in modern warfare, it is essential that the private ownership subsidy scheme for motor vehicles should be on a much more extensive scale than it was prior to 1914. During the early part of the war, large numbers of non-subsidy vehicles were pressed into service, and although these were confined to minor operations as far as possible, numerous difficulties and delays arose owing to the diversity of design, and to the rapid development of incipient defects under the unusually strenuous nature of service conditions. To avoid handicapping the services under similar circumstances in the future, the use of civilian-owned subsidy type vehicles should be greatly extended; and it is the duty of the private owner on the one hand to utilise vehicles coming under the subsidy as far as possible, and of the State on the other to encourage the use of such vehicles.

The specification of the War Department for the 30-cwt. subsidy type light lorry has just been issued, and presumably incorporates the experience gained by the various authorities during the war. The requirements regarding performance are doubtless severe, but no exception can be taken to this in view of the object of the specification. It is somewhat doubtful whether there is any vehicle at present on the market which would be capable of fulfilling all the requirements, though no doubt each separate requirement could be fulfilled by one or more existing vehicles. Price is rightly a secondary consideration in the case of war material, and there is no doubt that the price of a vehicle built to satisfy all the requirements of the specification must be relatively high. The designer who contemplates the manufacture of a vehicle for civilian ownership, but enrolled under the scheme, has therefore a somewhat difficult task. This point has evidently received careful consideration in drawing up the specification, as a number of the requirements are relaxed in contemplation of such circumstances.

The specification is divided into two parts, the first covering performance, and the second constructional detail, and a large part of the latter is applicable to all classes of motor vehicle, and may be studied with advantage by every designer who is anxious to improve his production. Dealing with the requirements regarding performance in the order of the specification, the engine must have a minimum swept-out volume of 3,500 c.c., and develop 35 h.p. at 1,400 r.p.m. It must be capable of being decarbonised by one man in five hours, and it must also be possible to remove and replace all big-end bearings in the same period. The consumption is not to exceed one gallon per 12 vehicle-miles. The temperature of the cooling water must not exceed 100 deg. F. above atmospheric after rather severe speed and hill-climbing tests. The petrol supply must be gravity fed, and be maintained with a nearly empty tank on a gradient of 1 in $4\frac{1}{2}$. The capacity of the tank must be sufficient for a 120-miles run. The car must be capable of stopping and restarting on a gradient of 1 in 5 fully loaded, and must climb a gradient of 1 in 10 on a good surface at 8 miles per hour for a quarter-mile. All controls must be free from binding with the vehicle fully loaded, and one front wheel jacked up clear of the ground. Tests will be carried out on rough ground, including loose sand 8 in. to 10 in. deep, and an 18-in. water splash with hard bottom. Either brake must permit of continual application for half a mile on an average gradient of 1 in 12 without overheating, and be capable of stopping the vehicle when fully loaded on a gradient of 1 in 5.

These requirements can only be regarded as reasonable in view of the service to which the vehicles may be put, and do not call for particular comment. The radiator and brake tests are certainly severe, and we doubt whether they could be met by many existing vehicles. They are, however, quite possible of attainment, and should be of great value in concentrating attention on two of the weakest points in the design of the modern vehicle. It must be remembered in considering the specification that after a civilian-owned vehicle has passed the tests, it is impossible for the authorities to keep it continually under inspection, and as the effectiveness of both the conventional radiator and the usual brake falls off rapidly with use, a high standard in the first instance is essential.

Turning now to constructional detail, it is evident that very careful attention has been given to the specification with a view to eliminating a number of defects which are prevalent in modern designs, and it is to these points more particularly that we would direct attention. Dealing first with the engine, it is stated that in the event of a gudgeon pin working loose, suitable arrangements must be made to ensure that it cannot score the cylinder wall. To engineers who have not had a wide experience of car engines such a demand will appear somewhat superfluous, as they would naturally assume that the makers themselves would give attention to such an obvious point, but the defect is in fact so common that special methods have been developed for treating the scored walls. The provision for a flywheel pointer for setting the valves and ignition comes in the same category, the majority of makers omitting this obvious fitting. In cases where timing chains are employed, it is stated that adjustment for wear or stretching must be provided. The absence of such means of adjustment is a frequent defect, and excessive noise and backlash are very common in engines with this form of timing gear. A jockey pulley is sometimes used, but it is doubtful whether this is as satisfactory as a train of gears which require no adjustment.

Dealing with the engine-oiling system, we regret that a stand pipe for inserting the oil is not insisted on. There are few engines which can be filled from an ordinary tin without a funnel, and the capacity above the strainer is usually so small that the majority of drivers remove the strainer before filling up. There appears to be absolutely no reason why the top of the filler pipe should not be level with the top of the engine, and have a sufficient capacity above the strainer to take a quart can of oil. This would save endless waste of time over a messy job, and might conceivably save the engine, if not the whole car, under critical service conditions.

Dynamo lighting is specified, although this is optional on civilian owner vehicles. It is to be of approved design, and we sincerely trust that many of the present designs, in which the terminal board and switches are compressed into the smallest possible space, will not be approved. It is not too much to ask that there should be a minimum of $\frac{1}{2}$ in. clearance between each terminal screw, and the board should be mounted in such a way that any wire can be located and detached without difficulty. The usual practice is to place the terminal screws close together in two horizontal rows, and the wires to the upper row shroud the lower terminals and make access to them most difficult. Considerable technical knowledge is usually necessary to locate the two bus-bars, which are generally merely two of the terminal screws, and there seems no reason why these should not be clearly marked. Each terminal might in fact have a distinctive letter or number, duplicated on the corresponding terminal on the battery, cut-out or dynamo. No mention is made of electrical starters, but it may be presumed that no objection would be taken to them if a non-detachable starting handle were fitted in addition. The use of such starters on commercial vehicles is at present very limited, but is likely to extend, as they result in an appreciable fuel economy. However rigid a driver's instructions may be, he will certainly frequently leave his engine ticking over unless provided with a starting motor.

One of the most striking departures from commonly accepted practice is in the specification of the radiator. This must be of the vertical straight-tube type with detachable top and bottom tanks, the tubes being not less than $\frac{5}{16}$-in. bore. We have already referred to the fact that the average radiator is one of the weakest points in the design of the modern car. It is doubtless highly efficient when it first leaves the works, but the efficiency rapidly falls off. After two or three years running it frequently commences to leak, and effective repairs can only be carried out by a specialist. A drain cock of not less $\frac{1}{2}$-in. bore is specified, in place of the usual inadequate $\frac{1}{8}$-in. or $\frac{1}{4}$-in. cock, and large filler cap and overflow pipes are insisted upon. A somewhat novel item is the provision of a strong bar or tube attached to the car frame and bridging the radiator, to reduce the risk of damage in the event of a collision. This is very rarely fitted at present, and considerable ingenuity will be required to design a fitting which looks at all neat on a light vehicle.

Neither multiple-disc nor leather-lined cone clutches will be accepted, and makers are thus reduced to the single plate, the expanding type, or the cone clutch lined with asbestos composition. There is no doubt that this is a wise provision for a vehicle of this class, though we are of opinion that the expanding type of clutch might also have been barred with advantage.

The gear-box must be of the four forward-speed type, and the gate must either be clearly marked, or a legible diagram showing the positions affixed to the dash. It would seem desirable to standardise the positions in the gate for all subsidy vehicles, as

neither of the devices referred to would be of any value in the dark unless a dash lamp were fitted. The use of a position indicator is often deprecated by drivers, as they appear to consider that it is a reflection on their intelligence. A subsidy vehicle may have to be taken over in an emergency by a driver who is an entire stranger to the car, and in such a case there may be no time to experiment with the gears. An oil-level plug or cock in the gear-box is specified, but this would hardly appear to be an essential where an inspection cover held on by wing nuts is already provided.

A somewhat novel feature is a power-driven tyre pump, which is optional on civilian-owned vehicles. We would suggest that some part of the connecting tube should be permanently attached to the chassis. Three-point suspension is specified for the engine and gear-box. The desirability of this form of mounting has long been realised, but it is very rarely attempted. The only practicable method of adopting the principle appears to be to use three ball joints, and this will add appreciably to the cost of the vehicle. The relative positions of clutch and brake pedals is specified, but the position of the throttle pedal is left optional. We believe it to be desirable that this position should also be standardised, as it is sometimes placed between the clutch and brake pedals, and sometimes to the right of the latter.

We are of opinion that few existing cars could fulfil the braking tests without difficulty, particularly that of continuous application of either brake for half a mile on a gradient of 1 in 12, the car being fully loaded, without overheating. No conditions are laid down as to the position of the brakes, and presumably front-wheel braking would be accepted. We trust that this is the case, as otherwise the universal use of such brakes will be retarded. This would be regrettable, as there must be a considerable number of fatal accidents each year which could be avoided if the additional retarding power of the front wheels were made available. No objection is raised to the transmission brake, but it would be difficult to design such a brake satisfactorily to fulfil the test for overheating mentioned, on account of its position preventing a free access of air to carry off the heat generated. We have referred in a previous article to the objectionable practice of utilising stranded wire for brake controls; this will not be permitted in the subsidy vehicle.

The specification states that oil lubrication throughout the chassis is desired, with wick-feed lubricators whenever possible. An injector system employing a thin grease lubricant will receive consideration as an alternative. We would suggest that if oil lubrication is adopted, the lubricators should be arranged in groups as far as possible, with feed pipes to the various units. Apart from the saving of time resulting from such an arrangement, the present practice of placing the lubricators directly on the bearing to be fed often results in their being placed in inaccessible positions. As a result they are frequently either deliberately neglected, or inadvertantly overlooked. It should not be necessary either to get under the vehicle, or to lift the floor boards, when oiling up any part of the chassis. The specification concludes with the requirements of the War Department regarding drawings and spare parts, and appendices give particulars of standards to be adopted, of the properties of the lubricating oils in use by the Department, and of the engine acceptance test.

THE DOMINION OF CANADA AT THE BRITISH EMPIRE EXHIBITION.

EVERYTHING that has been used in the construction of the Canada Pavilion except glass and cement was made or grown in Canada, and the whole of the work down to the actual installation of the exhibit, was done by the Canadian Commission without the help of sub-contractors. No pavilion in the entire Exhibition shows more clearly that it has been prepared by those who have a professional knowledge of the art of exhibiting. The impression, indeed, corresponds with the reality. For many years past the Dominion Government has had an Exhibition Department, and what they show at Wembley is merely a reproduction on a larger scale of what they have shown many times elsewhere. This is doubtless at least some part of the reason why the Canadian exhibit was one of the very few that were absolutely complete when the Exhibition was opened, and the personal presence of Mr. A. W. Toulmie, the Canadian Government Exhibition Commissioner, has warranted the view that the Government has done all that the prolonged experience of his department could suggest for the purposes it had in view. In our issue of April 25 we gave some indication of the extent of the remarkable display that has resulted from these efforts, and we propose now to indicate in somewhat more detail of what the display consists and what interpretation it is intended to bear.

It may be convenient to deal first with the general intention of the exhibit. A notable regulation observed in all parts of it is that no sales of any kind are conducted in the Pavilion. This regulation, whatever may be the reason for it, has a significant bearing on the purpose of Canada's participation in the Exhibition. Doubtless extended markets are sought for its products and its manufactures, but this object is essentially subsidiary. What is sought primarily is on the one hand pioneers to open out the boundless agricultural territories in the Dominion that as yet are undeveloped, and on the other hand capital to develop the enormous natural resources of which the large majority remain untouched.

To understand the full meaning of these needs it is desirable to remember the Dominion's circumstances. For this purpose an accurate perspective view is obtained more readily by avoiding exact statistics and looking at round figures; and the figures we give are therefore intentionally so expressed. The territory of Canada is larger by one-fourth than that of the United States, but its population is only just over nine million souls; and of these about one-half are collected in towns, with the balance of the entire population left for its 3,700,000 square miles. Over half the population is of British origin and over one-fourth of French, and there is no native problem at all. The birth rate is high—nearer 30 than 20 per cent. —and the death rate low, averaging 10·6 per cent., and in the Prairie provinces ranging from 7·4 to 8·4 per cent. These figures indicate that the climate is healthy, and an inspection of the figures of sunshine and rainfall bears out the statement that it is likewise pleasant, and for the most part favoured with a full but not torrential supply of rain. The actual extent of its water power, as of its forests and other natural resources, has been by no means fully ascertained, but they are known to be inordinately beyond anything of which the development has been attempted, and the use that has been made of them up to now has not been sufficient to prevent local shortages of power from time to time. Its primary industries—agricultural and pastoral, mineral, forestry, fisheries—and its manufactures, are not only large but almost without exception are steadily increasing. Great, however, as is its normal increase of population and production, the development of its natural resources is proceeding at a rate altogether inadequate to satisfy its national aspirations, and it seeks means and settlers suitable and adequate to speed up this development.

What, therefore, its exhibit of products is concerned to show, is not so much the detail of what it is producing as its abundance and variety. More than any other great Dominion, its exhibit expresses itself by carefully conceived panoramas, which, though adopting all that skilled art can do to beautify this style of presentation, aim at a more practical result than that of a merely beautiful effect. Fig. 1 shows an outline plan of the general lay-out of the Pavilion, the site of which is about 400 ft. long by 200 ft. deep. It is shown as it appears from the main entrances facing the lake, with the cardinal points reversed. Entering by the main entrance on the right of the frontage, the visitor is led to a large trophy of agricultural products, behind and to the right of which are courts devoted to minerals. Two fine panoramas, represent the operations respectively of the Hollinger gold mine and of a large nickel refinery, and illuminated transparencies form a frieze illustrating a variety of mining operations; the ceilings are supported on pillars of Canadian marble. The whole court, in fact, is made up of picturesque presentations of one aspect or other of mining. To those who are familiar with that industry the chief interest of the mineral exhibit lies, however, in the variety of specimens that are displayed both of metallic and of non-metallic minerals. These are taken from mines that either are or have been at work; and although by far the greater part of Canada is still unprospected, existing workings and the general exploration that has been made of its geological features show that, in addition to great districts already proved, it offers the prospector perhaps the largest area of promising mineral-bearing territory that remains unprospected at the present time.

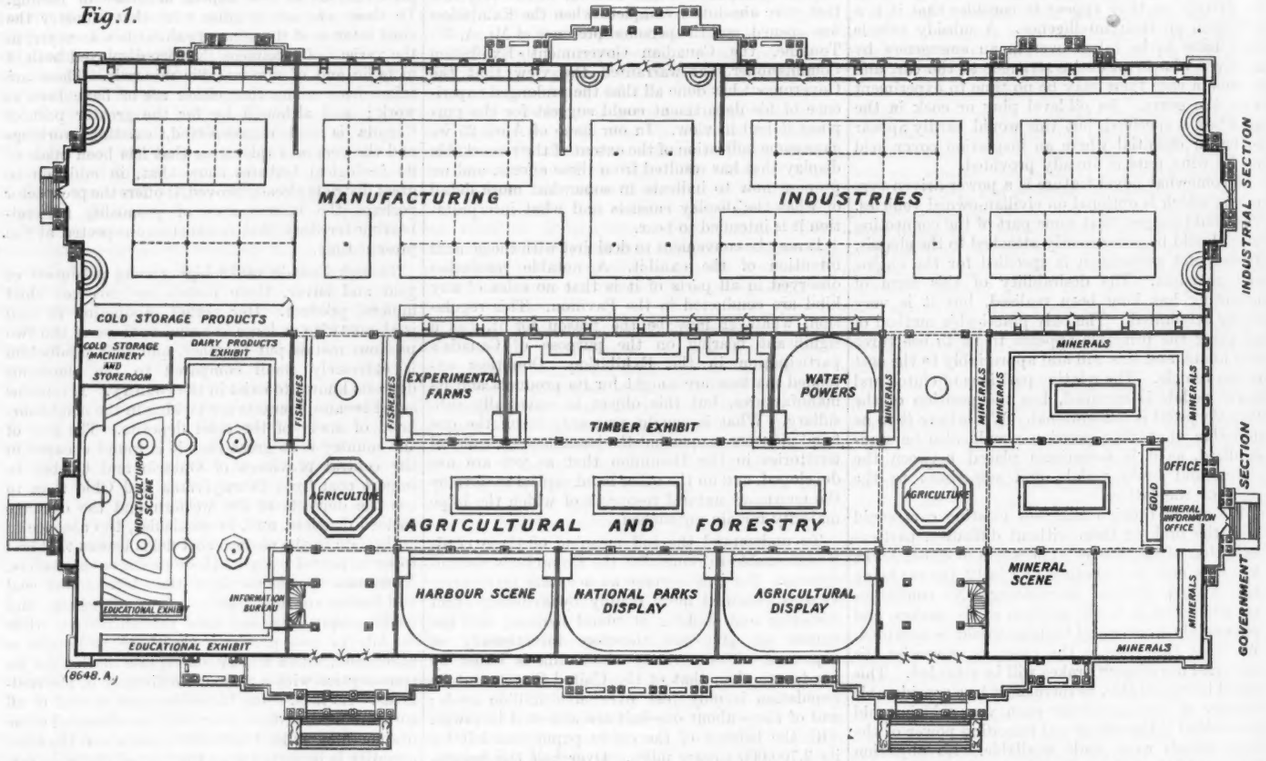
Though Canada ranks high among producers of gold and silver, these metals are not her chief mineral product. Her actual production of coal is about twice as large in value as those of the two precious metals put together, and that production is extremely small compared to the enormous deposits known to exist in the country. It remains small because markets are lacking in the neighbourhood of many of the chief deposits. The size of the country is so great that it is found cheaper in the central provinces of Ontario and Quebec to import coal from Pennsylvania and Ohio than to use the deposits of the western and the extreme eastern districts, and, in particular, the absence of anthracite in the eastern coal fields causes that fuel to be imported even in those districts themselves. Numerous specimens show that bituminous coal and lignite are found in a variety of regions, and could supply huge markets yet uncreated, while in Alberta and probably elsewhere anthracite is also found, with a wholly inadequate market for its consumption within reasonable distance of the coal-fields. As it is, some 15 million tons of coal of all sorts are produced per year, with an estimated value of something under 15,000,000*l.*, and about the same quantity is imported from the United States. Yet, apart from lignite and similar lower grade coals, Canada's deposits of bituminous coal and anthracite are estimated at 286,000 million metric tons. Canada's coal resources are, indeed, shown largely in her exhibits of pig iron and steel. For the most part the majority of her deposits of iron, so far as they have been tried, are of too low grade or too affected with impurities to be worked profitably; but her ample supplies of coal, lime, and fire-clay have enabled her to build up a great iron and steel industry mainly through smelting imported ores.

Numerous specimens are shown of gold and silver, including a 2-ton nugget of silver ore; the value of the output of both metals is something under 8,000,000*l.* Apart from them, the next most valuable mineral products are copper, nickel, lead, asbestos, and natural gas, all round about 1,000,000*l.* each: copper rather more and the others on the average a little less. The specimens of nickel ores and asbestos are of interest, partly because Canada is at present the largest producer of both these minerals, and partly because of the peculiar natural alloys of nickel and the remarkable quality of the asbestos. Another metal, as yet of minor economic consequence, of which Canada is the largest producer is cobalt, the annual output of which is about a fourth of the value of the copper production. Hopes that cobalt will come into wider demand for metallurgical uses seem to be indicated by the exhibition in this section of two cases of stellite, the 75 per cent. cobalt alloy with chromium and a little tungsten, which is shown as bars, weights, solid and inserted-tooth milling cutters, and forming cutters. A number of other metallic ores are shown, including those of the rare heavy metals, which occur in notable proportions in some of the principal nickel-copper ores, and are largely recovered at smelting works outside the Dominions where the matte is treated. Considerable and numerous deposits are also shown of economic clays, felspar, mica, and other minerals used in the structural, refractories, and ceramic trades. A general view of part of the mineral exhibits is given in Fig. 3 on page 139.

Adjoining the Minerals Court is a panorama representing some of the many sources of water power in the Dominion. Here again the history is

THE CANADIAN PAVILION AT THE BRITISH EMPIRE EXHIBITION.

Fig. 1.



of resources much larger than are being used—a matter naturally of the greater economic consequence because, unlike mineral deposits, the extent of water power available is not reduced by the quantity that is used. At the present time the whole of the water powers available in the Dominions have not been measured; but of those that have, amounting to over 40,000,000 h.p., turbines have been put in to utilise something under 6 per cent. The effect of the water power on Canadian industries and social economy is not seen separately in most of the exhibits. Two examples, however, show it clearly. As yet no commercial ores of aluminium have been found in Canada, though it is thought possible that the metal may ultimately be produced from some very pure native felspars; but specimens are shown of aluminium ingots, bars, &c., which Canada exports in quantity, in addition to providing for a large internal manufacture and some export of articles made out of the metal. A variety of artificial abrasives are also shown, both of the carborundum and the aluminous types, though all the bauxite and much of the silica sand used in their manufacture has to be imported. These instances are merely typical of other manufactures, in which what is sold is mainly the product of natural power.

Opposite the water-power panorama is another, which deals with agriculture. It is a good example of the way in which this form of exhibition is used to convey more serious information than is usually associated with it. In this panorama the leading economic processes used in the distribution of grain are clearly seen: the villages housing the workers, the cultivated fields, the elevators in which the grain is graded and stored, and the railway and ship communication by which it is transported. Other panoramas in this Court deal with the national parks, the harbours and the experimental farms, which at the present time are engaged in studying practically over 3,000 main experimental projects, most of them with sub-projects relating to practically all branches of the agricultural and pastoral industries. Their operations are of the more interest because most of the land under cultivation is owned by the farmers themselves, and also because as yet the preservation of fruit and vegetables has scarcely been begun, and the existing demand for production will undoubtedly increase when the preservation of the products for transportation has been reduced to practice. The Court also contains the main timber exhibit, representing an annual production of some 40,000,000*l.* value, and showing specimens of every commercial species of timber found in the Dominion. It includes micro-photographs showing sections of the number of typical Canadian woods, testing machines used in determining their mechanical properties, and samples of various distillation products. An interesting specimen is a wooden built-up hydraulic pipe armoured with wire, and a back about 12 ft. diameter, both in Douglas fir. In this Central Hall the frieze includes panels which, like the other decorations of the court, are ingeniously worked out in grains and grasses of various colours, and exhibit a considerable variety of aspects of Canadian life.

The eastern end of the hall—it will be remembered that on the plan this is to the left—is occupied principally with the important industries of fisheries and dairy products. The latter are represented principally by a vast display of butter, which is preserved by a refrigerating plant manufactured by the Linde-Canadian Refrigerating Company, Limited, of Montreal, installed under the direction of their engineer, Mr. S. R. Norland. This plant is driven by a three-phase induction motor manufactured by the Canadian Westinghouse Company, Limited, of Hamilton, and consists of a vertical enclosed-type 6½ in. by 6½ in. ammonia compressor, having a capacity of 10 tons of ice melted per 24 hours, with a range of condenser pipes in which the ammonia circulates outside a 1¼-in. water pipe. Among the features of interest in this design is a "safety head" arranged inside the cylinder cover under the control of a powerful spring, the head containing the delivery valve. The forced lubrication of the cross-head is controlled by automatic valves within an oil jacket in the base through which the main shaft runs. The compressor runs normally at a speed of 150 r.p.m.

The industrial section is composed partly of group exhibits and partly of those of individual firms. The most striking of the group exhibits are those devoted to the Canadian pulp and paper industry and the several British Columbia associations connected with timber and its products. A number of large specimens of Douglas fir are shown, and an endless variety of applications of this and other Canadian timbers. The scale in particular, on which paper-making is being conducted is illustrated in a reel 18 ft. 3 in. wide. The standard Canadian machine makes strips 15 ft. 6 in. wide at the rate of 1,090 ft. per minute, but the latest machines are said to be producing strips 19 ft. 4 in. wide at the rate of 880 ft. per minute, and one such machine has turned out as much as 196·6 tons per 24 hours. A British papermaking demonstration plant in the Palace of Industry shows, as the Canadian officer points out, a strip 36 in. wide made at the rate of 50 ft. per minute. With these exhibits may be taken one by the Hoard Company of Victoria, B.C., which consists of a silo so built up out of interlocking units that it is erected firmly without nails or connections of any kind. Another exhibit, by the H. R. Macmillan Export Company (Fig. 8, page 140), includes a section of a tree marked out to show the economical care with which timber is cut up (on the white lines) to the best advantage.

The steel-making industries are represented by two firms, the British Empire Steel Corporation and the Steel Company of Canada. The former shows products from ore to finished steel wire and wire products, with coal, limestone and refractories, and some variety of bars and sections. The latter ranges from pig-iron to wire rods and steel bars, with nails, bolts, galvanised pipes, drop forgings and by-products. Prominent among the purely engineering exhibits is that of the Canadian Ingersoll Rand Company (Fig. 7), which includes a petrol-driven portable air compressor, a belt-driven stationary air compressor, an air-operated forging and sharpening machine, a steam-driven direct-acting shaft pump, a steam or air-driven portable hoist, designed conveniently for a variety of purposes from those of mines to shipyards, and their well-known rock drills and pneumatic tools. Several firms from Galt (Ont.) show machine tools and similar products (Fig. 5). Thus the Canada Machinery Corporation show a back-geared crank shaper and a straight-edging saw. Messrs. Sheldons, Limited, show fans for ventilating, exhausting

THE CANADIAN PAVILION AT THE BRITISH EMPIRE EXHIBITION.

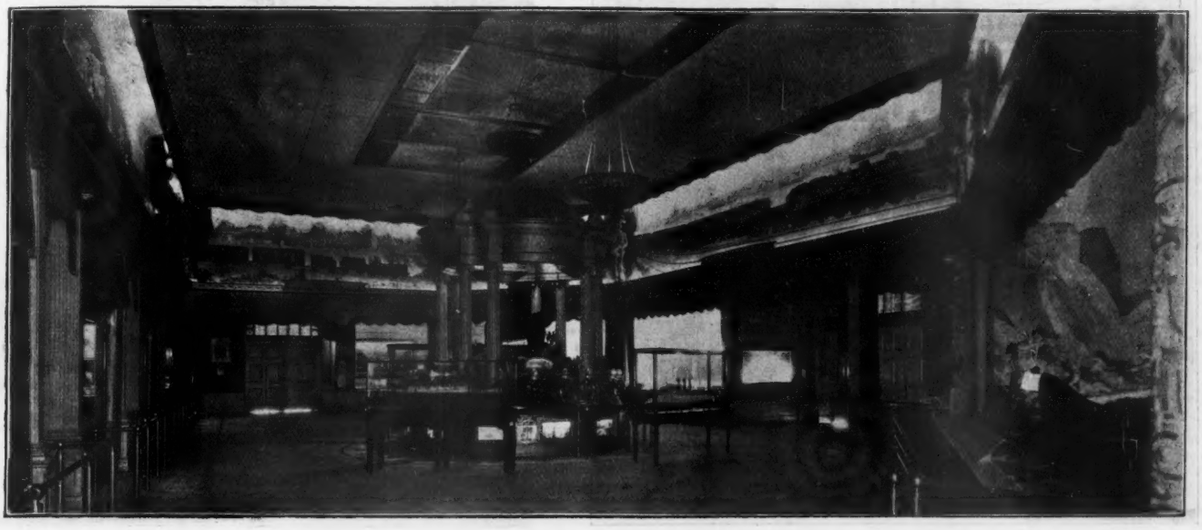


FIG. 2. VIEW IN INTERIOR OF PAVILION OF THE CANADIAN NATIONAL RAILWAY.

FIG. 3. PART OF THE MINERAL COURT, CANADIAN PAVILION.

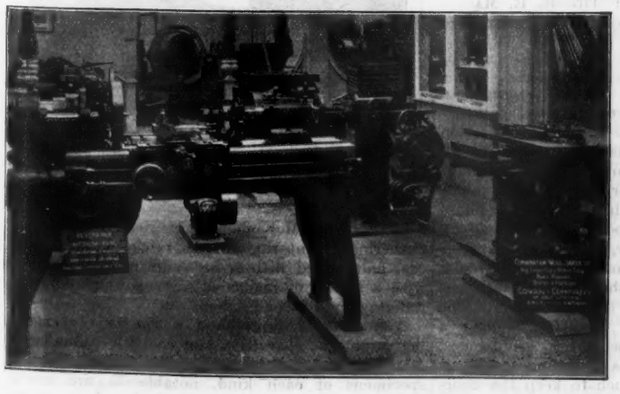


FIG. 4. MACHINE TOOLS; R. McDOUGALL COMPANY, LIMITED, AND COWAN AND COMPANY, LIMITED, GALT, ONTARIO.

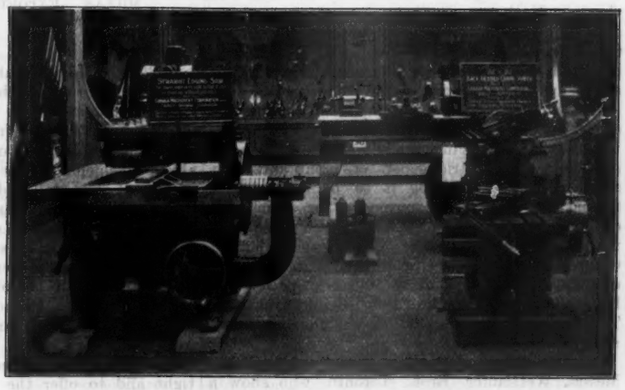


FIG. 5. EXHIBITS FROM GALT, ONTARIO.

THE CANADIAN PAVILION AT THE BRITISH EMPIRE EXHIBITION.

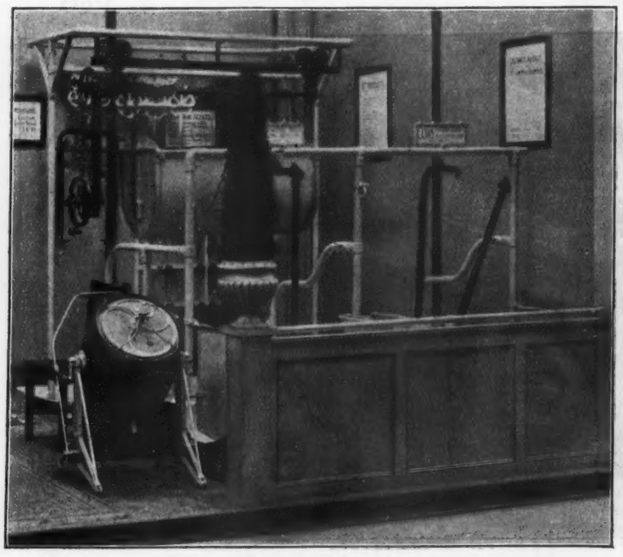


FIG. 6. WASHING MACHINES; MESSRS. BEATTY BROS., FERGUS, ONTARIO.

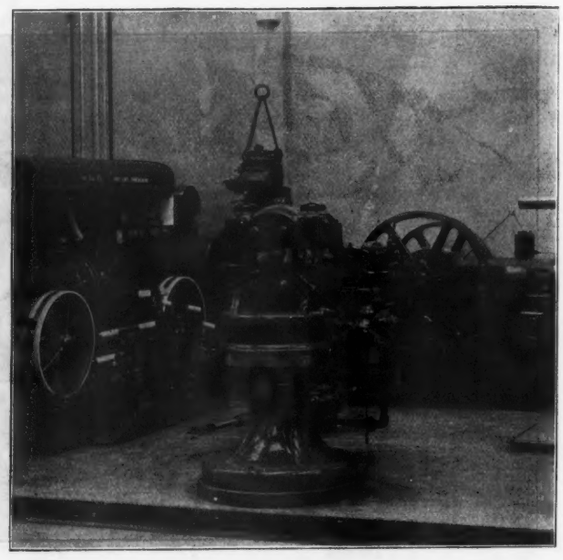


FIG. 7. AIR COMPRESSORS; CANADIAN INGERSOLL-RAND COMPANY, LIMITED, MONTREAL.

shavings, and pressure-blowing for cupolas, &c., and a reversible fan to be used for conveying, exhausting, or forge-blowing. The Shurly-Dietrich Company show a variety of saws with a special design of handle, and other hardware. The Galt Brass Company show tanks and plumbers' brass goods, and the Galt Machine and Screw Company automatic screw machine parts. Messrs. Cowan and Co., of Galt, show a combination wood-worker with rip, cross-cut and mitre saw, buzz planer, borer and mortiser, and an automatic vertical hollow-chisel mortiser. The R. McDougall Company (Fig. 4) show on the same stand a 14-in. engine lathe and a self-oiling pump. The Shurly Company, of St. Catherine, Ontario, also exhibit a large variety of saws, including some of vanadium steel. The Welland Vale Manufacturing Company show a variety of agricultural and garden tools; the hay and similar forks will be observed to have in some patterns many more prongs than the two that are usual in this country. The Dodge Manufacturing Company, of Canada are exhibiting a considerable selection of their fittings for power transmission, including their well-known wood split pulleys, introduced into this country by the Gandy Belt Manufacturing Company. Other familiar fittings are the gun-metal and steel valves of Messrs. Jenkins Bros., of Montreal, which are shown by the side of similar products of the Empire Brass Manufacturing Company, of London, Ontario.

Small stationary engines are represented by the Brantford oil engines, exhibited by the Ker and Goodwin Machinery Company, Brantford, Ontario, and domestic light, water and power plant by the Caron Brothers Inc. The former, which works with crude oil, is of the cold-starting, solid injection type and being made only in small powers is started by hand without requiring a compressed-air store or separate compressor. The Caron is a two-stroke, valveless petrol engine, made to give 3 h.p. and supplied with electric generator, pump and other small machines, enabling it to be applied to a remarkable variety of purposes, for which the extreme simplicity of its construction make it peculiarly suitable. The Canadian Linderman Company, Woodstock, Ontario, show, among other exhibits, a small combined electric power and light plant, as do the Delco-Light Company, Toronto, who also exhibit washing machines, refrigerators, and other articles.

Another type of machinery is exhibited by Messrs. Wettlaufer Bros., Toronto, who show a concrete-mixing machine and concrete brick

FIG. 8. CUTS IN TIMBER; THE H. R. MACMILLAN EXPORT COMPANY, LIMITED, VANCOUVER.

moulding machines, enabling builders to produce a high quality of cement brick on the site.

Messrs. Beatty Bros. (Fig. 6) show in operation examples of their washing machines, working with electric motor and by hand, and offering a considerable convenience to the user. They also show a variety of steel stall and stable fittings, cow-house equipment, and similar products. The Renfrew Refrigerator Company show, in particular, their Barnet refrigerating ice safe, in which an air circulation is set up, and prevents the contents from communicating their flavours to each other. The Richards Wilcox Canadian Company, among a large variety of hardware specialities, grindstones, &c., show their special types of sliding door gear, the design of which does much to keep the doors tight and to offer the fullest possible ventilation and the freest possible passage when the doors are

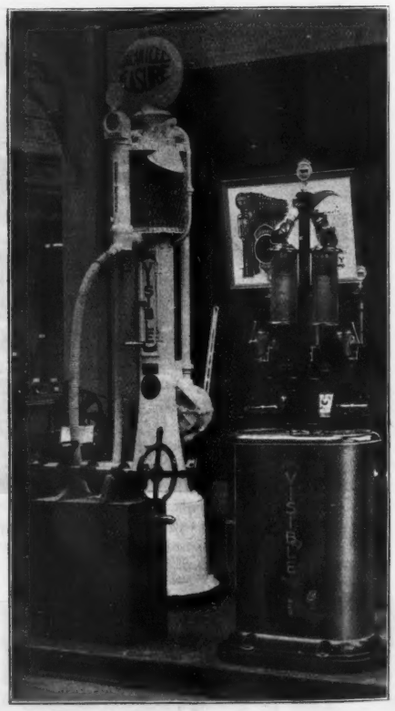


FIG. 9. VISIBLE PETROL METERS; MESSRS. PHILIP GIES FOUNDRY, KITCHENER, ONTARIO.

open. Messrs. McKinnon Industries, Limited, St. Catherine's, Ontario, show a range of malleable cast and forged fittings for saddlery and wagons, with a variety of malleable castings and forgings, radiators, and other products.

A number of firms show a variety of ranges both for gas, electricity and coal. The McClary Manufacturing Company, London, Ontario, shows specimens of each kind, notable—as are most Canadian stoves—for being made largely in steel instead of iron, and for showing a completely

enamelled internal lining in many types, removable for cleaning, and a well-insulated exterior. The electric variety has a patented heating element, in which the resistance wire is completely embedded in a clay with the same coefficient of expansion as the porcelain base within which it is wound. The coal stove has a convenient rotary arrangement of the bars for clearing the fire without poking. Other stoves are shown by Messrs. Clare Bros. and Co. Preston, Ontario, and the Happy Thought Foundry Company, Brantford, which show the same clean finish and a similar convenience of design. Other domestic conveniences are shown by the Hoover Suction Sweeper Company, Hamilton, who exhibit their well-known carpet sweepers, and the Taylor Forbes Company, Guelph, who, in addition to radiators and boilers for hot water and general hardware, show several types of lawn mowers and other horticultural appliances.

The Sheet Metal Products Company of Canada show a comprehensive collection of enamelled, galvanised, japanned, tinned, steel, copper and aluminium ware. The Steel Equipment Company, Ottawa, show an interesting line of steel office furniture, distinguished for its clean finish, both in a plain colour and in an imitation of wood. Messrs. Jones Bros. & Co., Toronto, exhibit an ingenious system of show and warehouse cases, built up out of units, which go together without nails, and can be extended by the addition of sections, or can be altered in arrangement with considerable convenience. The Goldie & McCulloch Company sent a number of safes of robust and careful design, the details of which are exhibited. In the motor car industry the Ford Motor Company of Canada has a large exhibit showing its most recent productions. General Motors of Canada, Limited, show the Cadillac, Chevrolet, Oakland and Buick cars, with a variety of equipment. The company turned out over 50,000 cars during last year. The Gotfredson chassis, designed primarily for charabancs and similar uses, is also exhibited. Messrs. Willys-Overland, Limited, of Toronto, show their Overland and Willis-Knight cars. Tyres are shown by Guttapercha and Rubber, Limited, the Firestone Tire and Rubber Company, of Canada, the Dominion Rubber Company, K. and S. Tire and Rubber Goods, Limited, together with other varied rubber products, which also are shown by the Sterling Rubber Company. A useful range of appliances for distributing petrol and similar purposes is shown on the stand of the Gies Foundry (Fig. 9) by the Fry Petrol Pump Company of Wembley. One of their devices for distributing petrol or lubricating oil is seen in front. The liquid is delivered into a transparent container, which discharges through an overflow pipe consisting of a telescopic tube, arranged to be moved vertically within two glands by a handle keyed to it. This handle can be inserted into notches at various heights, previously calibrated by a Government Inspector to deliver specified quantities, the notches being then sealed.

At each end of the main Pavilion are separate pavilions erected respectively by the Canadian National (Fig. 2) and the Canadian Pacific lines. Perhaps the most remarkable of the Canadian National exhibits is their mountain type locomotive of which they show a drawing, representing 16 engines already built by the Canadian Locomotive Company. Its height and overhang have made it impossible to bring it over English lines, as was at first intended. It weighs with its tender over 290 tons, has eight driving wheels 73 in. diameter, a maximum inside diameter of boiler of 7 ft. 6 in. and a length of 90 ft. for locomotive and tender. The cylinders are 26 in. diameter by 30 in. stroke, and the boiler pressure is 210 lb. The locomotives cost 100,000 dols. each, and are said to be thoroughly satisfactory.

The main line permanent way is in their favour from coast to coast, the gradients being light even in passing through the Rocky Mountains. A feature of the National system is that all through trains are built wholly of steel. The system, which extends over 22,000 miles, operates eight broadcasting stations, and every chair in its observation car is fitted with ear-phones. The exhibit includes sections of the various types of compartments in the cross-country car, which illustrate how much convenience is at the disposal of all travellers, from settlers onwards. The Canadian Pacific Pavilion, in common with the Canadian National, devotes a great deal of space to exhibiting the attractions of the country and the magnitude and variety of its resources. There are throughout the Exhibition a number of illuminated maps, arranged so as to spot out the localities where particular resources are to be found at the same time as the details are given on illuminated panels. The Canadian Pacific exhibit includes one such map, which is among the most elaborate. It can be worked by hand, picking out whichever resources are in question, but normally it operates them all successively by an automatic arrangement. Among other particulars it gives the whole of the line of railways on the Continent, including the Canadian National system, its friendly competitor; the rail lines and some other particulars are exhibited through transparencies behind small perforations in the map, while the legends, the cities and some other details are shown by little telephone lamps. Like everything else in the case, it was made completely in Canada, and was erected by a Canadian electrician, Mr. Petitclerc.

THE LATE SIR W. A. HERDMAN.

THE sudden death, on Monday, of Sir W. A. Herdman, for many years one of the general secretaries of the British Association, and its President at Cardiff in 1920, will be widely regretted, especially by members of the Association, for the Toronto meeting of which he was to sail this morning.

William Abbott Herdman was born on September 8, 1858, in Edinburgh, where he received his University training as a biologist. He was too young to take part in the Challenger Expedition of 1872–76, but as assistant to Sir Wyville Thomson he published three volumes of one of the reports on the expedition. In 1891 he went to Liverpool as Professor of Natural History, and in 1919 he became Professor of Oceanography there; the new chair, which he occupied till 1922, had been endowed by himself. His second wife, Miss Jane Brandeth Holt, who died in 1922, and he himself were liberal donors to Liverpool University; their first donation of 10,000*l.*, was made in memory of their only son, who was killed in the war. Professor Herdman was president of Section D, Zoology, of the British Association at Ipswich in 1895. He promoted the work of the dredging committee of the Association, which his teacher, Edward Forbes, had originated in 1839. He established the Marine Biological Station at Port Erin, Isle of Man, and the Sea-Fish Hatchery at Piel, near Barrow; and he was Honorary Director of Scientific Work to the Lancashire Sea-Fisheries Committee. In 1901 the Government sent him to Ceylon to investigate the pearl-oyster fisheries. Plankton, the floating minute life of the sea, was later his favourite study. In 1903 he joined Major MacMahon as general secretary of the British Association, in whose work he took a very active share. In his presidential address at Cardiff on "Oceanography and Sea Fisheries" he defined oceanography as one of the two branches of physiography, geography being the other branch, and he advocated a second Challenger expedition. He was President of the Linnean Society in 1904, and held honorary degrees from Harvard University and from the Australian Universities, which the Association visited in 1914, and others. His knighthood dates from 1922.

INDUSTRIAL NOTES.

A CONFERENCE of the trades unions connected with the engineering trades has been called for on July 31, in order to discuss what action shall be taken in view of the inability of the employers to grant the advance of 1*l.* a week demanded. It is, we think, generally admitted that skilled mechanics are now at a serious disadvantage as compared with unskilled labour, of which the emoluments have increased proportionately to a much greater degree than in the case of the skilled men. The fact is highly regrettable, but on the same basis the professional classes have a still stronger grievance. Ultimately no doubt matters will adjust themselves to relative fairness, as was approximately the case in pre-war conditions. In the meantime, however, it is not surprising that the skilled men are restive under the inequity of the present conditions, but it is to be hoped that no drastic action will be taken. Trade disputes must increase costs of production and thus make less available for distribution as wages. In part, the men concerned cannot be entirely acquitted of blame for the present unsatisfactory amount of their pay. For many years they resented the introduction of improved processes and methods of manufacture, oblivious of the fact that the successful exploitation of these would naturally and inevitably lead to a wage increase. The idea widely held was that new processes and machines were admissible only provided they did not diminish labour costs per piece. On the other hand, employers generally in the past have refused to share at the outset any gain thus achieved, so that the workman gained nothing by the improvement until the resultant increase of prosperity led to a general increase in wages.

The engineering employers are in the present instance perturbed by the prospect of very serious German competition so soon as the mark is stabilised. Fortunately there seems a fair chance that excessive competition thus arising may be somewhat indefinitely postponed. It will be remembered that the German manufacturers some little time since were exulting in the fact that they had paid off debentures and other prior charges on their establishments by worthless paper marks. It has been stated, whether correctly or not we do not know, that no inconsiderable proportion of these debentures were held by non-Germans and that the operation in question implied the virtual confiscation of many millions of non-German wealth. The maxim that honesty is the best policy seems, however, likely to be vindicated once again since it appears that Germany is now finding great difficulty in securing new industrial capital. According to a recent speech by Herr Hamm, rates of interest are now higher in Germany than in any other trading country. From a Swiss informant, we hear, indeed, that no less than 30 per cent. has been demanded for supplies of capital to German industrialists. From Herr Hamm's statement it is further evident that Germany hopes by her tariff arrangements to secure means of bargaining on favourable terms with countries from which she requires supplies. Many of these are British Dominions.

The relatively poor prospects for skilled mechanics in this country is leading them to emigrate in considerable numbers. This matter was specifically referred to by Colonel O. C. Armstrong in his address last Tuesday to the shareholders of Messrs. Greenwood and Batley, Limited. He expressed the fear that when the tide turned, this loss of skilled hands might be severely felt. In the past, however, we have undoubtedly used our skilled men very uneconomically, effecting by manual dexterity work that might better have been done by semi-skilled labour operating machines. No doubt, this latter system is best suited to mass production. Not all demands can, however, be met by mass production. Many machines and engines are made only in small numbers, and we have undoubtedly gained not a little in the past by the fact that the skill of our workmen made it possible to produce work of this kind relatively cheaply. Moreover, repairs can only be effected by skilled men, and this fact has probably had its influence on American practice, where, according to all accounts, machines which would in this country be repaired and kept in service are there discarded and replaced by new.

In no department have we reaped more advantage from the skill of our workmen than in shipbuilding, where operations were successfully performed by hand that in foreign yards could only be economically tackled by special machines. This condition is, however, not without its dangers, and at a meeting of the Naval Architects two or three years ago a North Country shipbuilder, who had just returned from a visit to a Dutch shipyard, declared that after seeing the excellence of the arrangements there, he had come to the conclusion that he knew nothing about shipbuilding. In this connection it may be noted that on Tyneside considerable comment has been aroused by the recent placing of orders in Holland for three steamers at a price 11,500*l.* below the lowest British tender. In some quarters the difference has been in part attributed to the "vexatious regulations" of the Shipbuilding Trade Unions. Mr. John Hill, General Secretary to the Boilermakers' Society, denies this, saying that his society has "no 'ca'canny' rules to hide." This observation is obviously open to more than one interpretation, but whether "hidden" or not it cannot be denied that his union has been guilty of such practices in the past. When, for example, an electric welding process was introduced for certain work, the claim was made and enforced that, as this work had been previously done by riveters, a complete riveter's gang of four men must be employed to operate the new method, though only one man was really needed for the work.

The threatened electrical strike is hardly calculated to further the projects in hand for the greater use of electrical power. Some few decades ago an American railroad magnate aroused widespread reprobation by the callous observation (*re* some proposed ameliorations in railroad conditions) that "the public be

damned." Unfortunately, there have of late been numerous instances which would seem to indicate that this phrase has been taken as the effective, if unofficial, motto of the Electrical Trades Unions. Great concentrations of power in super-stations would undoubtedly put the union in a position to blackmail the public, and too oft "the sight of means to do ill deeds makes ill deeds done." The recent action of the Union at Fulham, where they threatened to pull the switches unless certain proposed changes in the conditions of employment of the dustmen were abandoned, shows clearly what the public may expect if it becomes dependent on super-stations for its power supplies. It is now definitely announced that unless the demands of the men are granted the strike will extend to the transport services, as well as to other electrical undertakings. The weak point of the Electrical Trades Unions lies in the fact that there are any number of competent volunteers who could do the work, if anything, probably somewhat better than the regular hands, and if granted protection against violence, the essential services of the country could be carried on.

LETTERS TO THE EDITOR.

ERSTE BRUNNER TURBINE.

To the Editor of Engineering.

SIR,—In certain issues of your valued paper during this last year some information has appeared about the newly developed Erste Brunner turbine. Claims have been made that in designing this turbine some new fundamental principles have been utilised to secure a higher efficiency than hitherto obtained with any other type of turbine. These principles (among which is specially mentioned striving for a "high-quality factor"), however, are well known to every turbine designer.

In consequence of the test results on a high-pressure turbine, the assertion has been repeatedly made that the new Erste Brunner turbine has not been surpassed as regards economy, but this is not the case. More than ten years ago turbines were built on the Ljungström principle, which all show comparatively better results than the Erste Brunner turbine. As an example, a Stal-Ljungström turbine delivered to Luton in 1916 might be mentioned. At official tests carried out with this turbine by the engineering firm "Mekaniska Provningsanstalten," Stockholm, the following results were obtained :—

Extract from the Official Report on a 3,000-*kw. Stal Turbo-generator supplied to the Luton Corporation, Luton, England.*

Normal Output	3,000 kw.		
Test number	1	2	3
Test lasted, minutes ..	31·67	29·30	14·25
Absolute steam pressure after throttle valve, kg. per cm.²	9·31	6·17	1·87
Steam temperature after throttle valve, deg. C. ..	353·4	350·4	304·5
Vacuum in turbine casing, kg. per cm.²	0·0859	0·0585	0·0233
Temperature of cooling water at outlet, deg. C.	34·17	28·16	10
Temperature of condensed steam in measuring tanks, deg. C.	46·17	43·36	35·25
Steam condensed during test, kg.	7,300	4,264	612
Generator output, kw. ..	2,720	1,594	292
Speed, r.p.m.	3,000	3,000	3,000
Steam consumption, kg. per kw.-hour	5·07	5·44	8·61
Generator efficiency, per cent.	94·5	91·9	68·4
Thermo-dynamic efficiency of the turbine, per cent. ..	87·4	84·9	80·3

MEKANISKA PROVNINGSANSTALTEN.
(Signed) AXEL. F. ENSTROM.
Stockholm, January 19, 1916.

It is remarkable that an efficiency of only 84 per cent. to 85 per cent. was obtained with the Erste Brunner high-pressure turbine in question, which was allowed to work under perfect ideal conditions. A Ljungström turbine built for the same working conditions shows a corresponding figure of 90 per cent.

For all reasons it is evident that the highest possible "quality factor" should be aimed at in building an efficient turbine. It is, however, astonishing that the designers, in spite of this rule, are employing the impulse principle, as the quality factor of impulse turbines theoretically is materially limited in comparison with that of reaction turbines.

The idea of dividing the heat drop between many rows in the high-pressure part of a turbine is not a new one. This method has been employed for many years in the Parsons as well as in the Ljungström turbine. The precautions taken to reduce the disc friction in the Erste Brunner turbine are certainly right; a much more effective solution of this problem, however, is to be found in the radial-flow Ljungström turbine. The latter type of machine, by reason of its mechanical construction, must necessarily operate with less disc friction, leakage losses, bearing friction, ventilation losses, and radiation losses than any turbine of the Erste Brunner design, as every one conversant with steam turbines must admit. Hence it is reasonable to expect a higher thermal efficiency for the former design, and this anticipation is borne out in practice.

From what has been said above it is obvious that no new remarkable results have been obtained with the Erste Brunner turbine, and the assertion that new ideas and principles have been for the first time practically realised in this turbine cannot be substantiated.

O. WIBERG.

July 18, 1924.

MAXIMUM POTENTIAL GRADIENTS.

To the Editor of Engineering.

SIR,—In Mr. Llewllyn B. Atkinson's very valuable paper on the subject of cables, contributed at the World Power Conference, remarks were made—though I am sure they were not made with that object—which might lead one to imagine that every effort to meet the conditions in extra high-tension cables by seeking to distribute the maximum potential gradients through the cable was based upon insecure or, at least, questionable premises.

I quite believe that what Mr. Atkinson had primarily in mind were the attempts which have been made—whether by introducing different impregnating substances into the paper at different distances from the copper core, or by using materials having different dielectric constants—to make the potential gradients more uniform through the cable. Moreover, the allusions which he made during the discussion to the fact that cables having copper cores of small diameter had stood up without breakdown to dielectric stresses which, calculated according to the recognised formulæ, must have been very considerable, need not, I submit, cause any misgiving.

In whatever degree practice seems to depart from theory as regards these effects on very small copper cores, the departure is all in the direction of what I may call the "safe" side. Hence, it follows that if, as I have done, cables are calculated out on the basis of making the maximum potential gradient a quite reasonable amount and one that is known to be safe with larger cables, no worse result will obtain than what has already been found, viz. that the cable will do its work excellently.

The point which, however, I desire to emphasise is that, when we come to single-core cables intended for, say, 130,000 volts, in which the makers have reached absolutely the limit of depth to which they can satisfactorily impregnate the insulation, whether those cables have been designed on the maximum gradient theory or the average gradient theory is of no moment as regards further progress. The fact remains that in any case the makers have reached the limits to which they can impregnate.

If now it be granted that it is possible to take away the cable at this stage, before the lead sheath is put on, and to introduce two "intersheaths" in the way that I propose to do for the "Hexaphase" system, and if these intersheaths are of such a large diameter that there is a comparatively small difference between their minimum and their maximum stresses, then a great gain has immediately been made, quite above any challenge whatever.

The whole point at issue is whether the central insulation of the cable can be made to withstand two separate impregnations. The cable to which I alluded the other day proves conclusively that this can be done; it also proves that these intersheaths may each be of the order of thickness of 0·3 in. and that they can withstand some 35,000 volts apiece; which multiplied by $\sqrt{3}$ gives 121,000 volts of transmission. This has been added to the original 130,000 volts, after the single-core advocates have confessedly reached the end of their tether, by the simple expedient of the two intersheaths, and we obtain immediately a cable, subject to the joint question being satisfactorily solved, suitable for a voltage of 250,000 volts, without exceeding a maximum potential gradient anywhere of more than 50 kv./cm., and this, too, with a 0·15 sq. in. copper core.

As already pointed out, a cable has been made, designed only for 150,000 volts, which has come through "smiling" after a test equivalent to 338,000 volts, maintained for three-quarters of an hour; and, working on identical lines and similar calculations (which, as I have already shown, err on the safe side), we ought to be able to design a cable for 220,000 volts with an overall diameter under the lead of 4½ in. or, say, 5¼ in. over the lead.

In any case, a cable has been made which appears to be thoroughly serviceable for 150,000 volts, and is only 2¾ in. diameter under the lead. This, I believe, it is quite beyond the possibility of single-core cables to accomplish for equal limiting stress and for an equally small core cross section.

Yours faithfully,
A. M. TAYLOR, Major.
"Slade Lodge," Erdington, Birmingham.
July 18, 1924.

PHOTOGRAPHIC SURVEYING.

A METHOD of surveying by photography, devised by Mr. J. W. Gordon, K.C., enables plans, elevations, levels and contours to be produced to any desired scale. The method—for which simplicity, reduction of field work, permanency of records, and ease of transport of apparatus are claimed as advantages—is based upon the theory of generalised linear perspective, with which Mr. Gordon has dealt in a book reviewed on page 692 of our 115th volume. It is not possible, in the space at our disposal, to describe the method in detail, but we may say that it employs a special form of fixed-focus camera taking 5 in. by 4 in. plates and mounted on a stand so that it can be levelled or directed to any desired angle with the horizontal. Arrangements are also made so that data, such as the station number, angle of dip, compass bearing, &c., can be impressed upon the plate, together with the image of the area of ground to be surveyed.

One method of procedure is to take photographs from two points at a known distance apart, usually 30 ft., and determine the displacement between a corresponding point in the two photographs due to parallax. From the measured displacement of the image, knowing the focal length of the lens, and the angle of dip of the optical axis, it is possible to calculate the level of any point, and also to locate it completely in the horizontal plane. Similar results can be obtained from a single photograph by employing "beacons," in the form of 6 ft. laths, painted white and placed in the required positions on the ground before making the exposure. A special form of comparator for measuring parallax and a simplified form of pantograph to facilitate the work of plotting points from a photograph on to a plan have been devised by Mr. Gordon, whose address is 11, King's Bench Walk, Temple, London, E.C.

BRITISH ENGINEERING STANDARDS ASSOCIATION.—Publication No. 204—1924 on "Terms and Definitions used in connection with Telegraphs and Telephones," which has just been issued, forms one of the 11 sections of the British Standard Glossary of Terms used in Electrical Engineering to be completed shortly by the Association. The definitions in this section have been drawn up in co-operation with the American Institute of Electrical Engineers and the American Engineering Standards Committees, thus ensuring uniformity in nomenclature as far as possible among telegraph and telephone engineers in this country and the United States. The list contains definitions of about 230 terms, grouped into eight subsections to facilitate easy reference. An alphabetical index is also included giving full cross-references. A second pamphlet, "Magnetos for Internal-Combustion Engines," numbered 5027—1924, covers four types of magnetos used for internal-combustion engines, excluding those for aircraft purposes. The dimensions standardised are those which effect the interchangeability of magnetos as a whole. Full particulars, with diagrams, are given for the plug and ring gauges for checking the taper in the magneto coupling and on the armature spindle. Copies of both publications are obtainable from the B.E.S.A., Publications Department, 28, Victoria Street, S.W. 1.; price 1*s.* 2*d.*, post free.

AUSTRALIA.—Statistics for the quarter ending March, last have been published by the Department of Overseas Trade. The total value of imports from all countries was 36,507,484*l.*, the figures being 37,206,966*l.* for the quarter ended December 31, 1923, and 33,776,258*l.* for the first quarter of 1923. The following comparative table shows the total value of trade secured by the chief competing countries :—

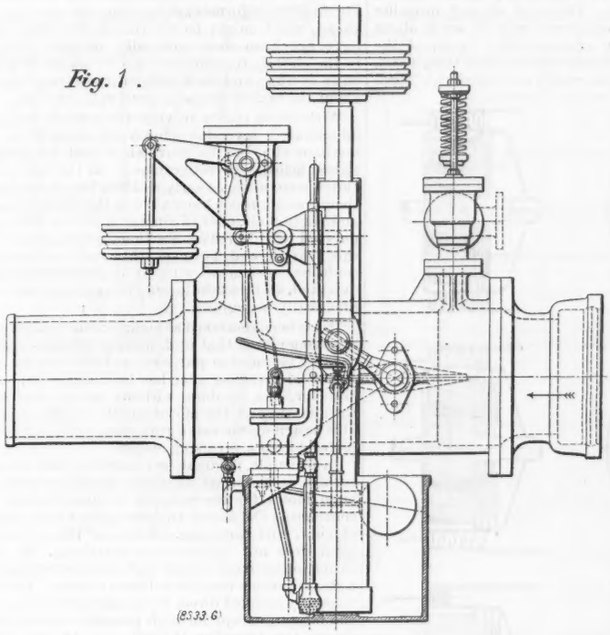
Country of Origin.	March 31, 1924.	December 31, 1923.	Quarter ended March 31, 1923.
United Kingdom ..	16,610,522	17,710,600	18,476,298
Canada	1,358,638	1,325,946	1,389,877
Germany	402,985	412,471	157,982
Japan	837,791	886,091	751,633
U.S.A.	8,730,421	8,456,443	5,938,024

From these figures it is apparent that the improvement in imports from this country in the final quarter of last year has not been maintained, the value having declined by 1,100,000*l.* German and Japanese imports have decreased slightly, while those from Canada and the United States of America have registered increases. Complete details are available at the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, and may be obtained on referring to C.X. 1085.

AUTOMATIC SELF-CLOSING THROTTLE VALVE FOR PIPE LINES.

CONSTRUCTED BY MESSRS. GLENFIELD AND KENNEDY, LIMITED, ENGINEERS, KILMARNOCK.

Fig. 1.



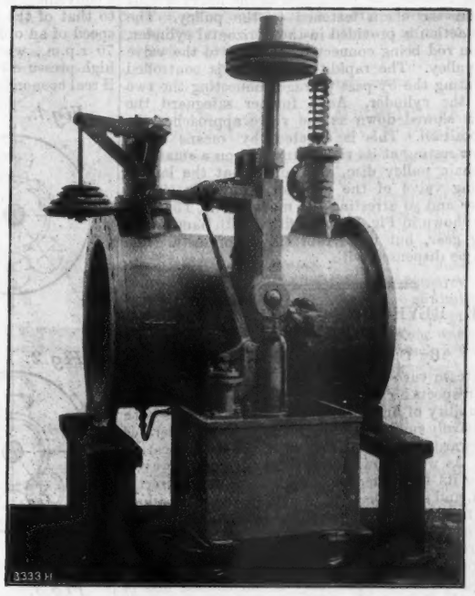


FIG. 2. 24-IN. SELF-ACTING THROTTLE VALVE FOR DUNFERMLINE DISTRICT WATER SUPPLY.

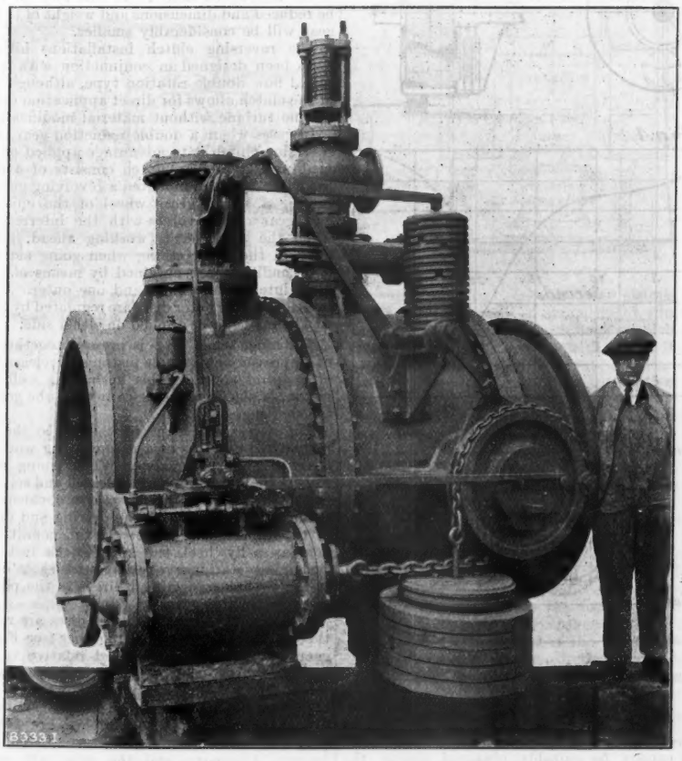


FIG. 3. 49-IN. SELF-ACTING THROTTLE FOR THE TASMANIAN HYDRO-ELECTRIC SCHEME.

AUTOMATIC SELF-CLOSING THROTTLE VALVES FOR PIPE LINES.

IN all installations making use of a high head of water it is desirable to introduce safeguards against damage arising from the failure of a main, or some other contingency which would result in waste and flooding, as well as involve risk to plant. Among the most important of such safeguards are automatic self-closing throttle valves provided at different points in the pipe lines. These operate on the water velocity exceeding a predetermined figure, and anything which would cause such a velocity to be attained, such as the racing of the turbine or the bursting of a main, will result in that particular line being cut out automatically after the passage of a certain amount of water.

Typical valves of this class, manufactured by Messrs. Glenfield and Kennedy, Limited, of Kilmarnock, are illustrated in Figs. 1 to 3 annexed, and though different in design the automatic action of both these patterns will be clear from reference to Fig. 1. In this illustration will be seen, at the left-hand end of the valve casting, a column closed at the top by means of a blank flange. Inside this, from the top, is hung an arm having at its lower end a disc, which is arranged across the line of flow in the pipe. The disc is counterbalanced by external weights, and takes up, under normal conditions, a certain position in which it is swung over to the right as in Fig. 1. Should the velocity of flow exceed the predetermined amount, the pressure on the disc will swing the arm over to the left, and this results in the tripping of a short double-armed horizontal lever, shown in Fig. 1, below the triangular counter-weight lever. The right-hand end of the double-arm lever normally holds in a raised position a vertical piston rod, loaded at its upper end, and at its lower fitted with a piston and dash-pot cylinder, the bottom of which is contained in a small tank with ball float valve to ensure the presence of water. On the small lever being tripped, the piston is free to drop under the action of the load against the resistance offered by the dash-pot, which is capable of regulation by means of a small relief valve. The throttle valve in the pipe will be seen to be fitted with an external arm, the end of which slides in a pivot inserted in the vertical piston rod, and on the rod moving downwards the throttle is gradually turned to the closed position. A relief valve is fitted on the up-stream side of the throttle. The remaining gear, to be seen in Figs. 1 and 2, consists of a small hydraulic hand pump for use in resetting. To accomplish this operation, the dash-pot relief valve is closed and the hand pump used to force water into the dash-pot cylinder below the piston. The piston rod is thus raised, and the trip levers can be reset. The small relief valve is held closed temporarily during this process by means of a short lever close to the pump handle.

The valve shown in Fig. 3 is one of the larger sizes, being, in fact, a 49-in. valve, which, however, is not by any means the largest size made. It is of some particular interest at the moment, as it shows a type of valve made by Messrs. Glenfield and Kennedy for Messrs. Boving and Co., Limited, for the Great Lake Hydro-Electric Scheme of Tasmania, a description of which has recently appeared in our columns, through the courtesy of Mr. J. H. Butters, C.M.G., Chief Engineer and General Manager of the State Hydro-Electric Department of Tasmania. These valves are intended to work under a head of 200 ft., and are tested to 400 ft. The normal velocity of the flow in the pipes is 12 ft. per second, and if by any

mischance this increases to 17 ft. per second, the valve will trip and close automatically. In this instance, the trip engages with an inclined lever, the lower end of which holds back a stop on a chain pulley keyed to the main valve shaft. The valve is closed on this stop being released, by the action of the heavy weight below and the chain fastened to the pulley. The dash-pot action is provided in the horizontal cylinder, the piston rod being connected by chain to the valve spindle pulley. The rapidity of action is controlled by regulating the by-pass passage connecting the two ends of the cylinder. As a further safeguard the motion is slowed down as the valve approaches the closed position. This is effected by means of a long lever resting at its right-hand end on a small pin in the chain pulley disc, and coupled at the left to the timing valve of the cylinder, gradually closing this valve and so arresting the movement. The type of valve shown in Fig. 3 is also fitted with hand-pump resetting gear, but in certain classes of installation this can be dispensed with.

THE REVERSING-CLUTCH MARINE TURBINE.*

By O. A. WIBERG (Sweden).

THE steam turbine has proved to be very suitable in many respects for ship propulsion purposes. Through the possibility of building units of larger outputs with comparatively small dimensions it means a considerable step forward in comparison with the reciprocating engine. As well known, the steam turbine, however, owing to its fundamental design, cannot be directly reversed, and it has been necessary, therefore, to adopt special means for this purpose. The method most extensively used is to instal separate astern turbines, which are put in service only for the reversing action. This arrangement, however, involves a series of disadvantages among which may be mentioned loss of power and efficiency due to the ventilating action of the reverse turbine when going ahead; heating and expansion troubles during manœuvring, and difficulties in utilising highly superheated steam.

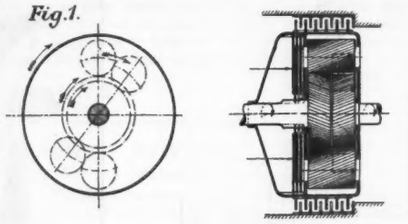
Another cause of loss of efficiency is to be found in the need of ampler clearance on account of the uneven expansion due to the sudden variations of temperature when manœuvring. If the turbine has been running ahead for a period sufficiently long to establish stability in respect to temperatures, the last blade row of the astern turbine has the temperature of the condenser. At a sudden reversing of the turbine, the astern turbine during the first seconds has to absorb the whole kinetic energy of the ahead turbine, the reduction gear, the propeller and the energy imparted to the propeller by the vessel's movement.

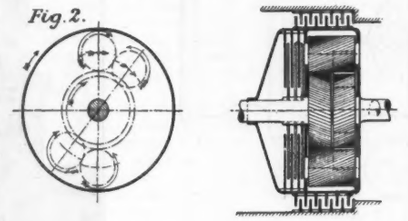
The heat corresponding to the whole of the energy must be absorbed by the only medium available, viz., the steam admitted to the astern turbine, and thus the temperature of the steam must rise instead of fall during its passage through the astern turbine. The low pressure parts of the turbine during the first period of the reversing process thus will be exposed to steam of a temperature which is generally higher than the admission temperature and a sudden, considerable rise in temperature of these parts is unavoidable. Investigations have shown that the strains set up in the disc on such occasions are considerably in excess of the normal centrifugal stresses, even if the increase in temperature is less than what may reasonably be expected. These strains, of course, are not of a nature to cause an immediate fracture and they generally result merely in a slight deformation of the disc.

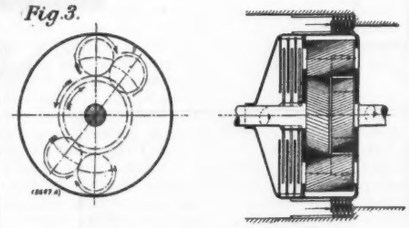
The difficulties are of less importance if steam of lower superheat or saturated steam is used, and one of the reasons why high superheating is not recommended for marine purposes is probably to be found in these reversing difficulties. As is well known, there has been a marked endeavour in the last few years to use still higher temperatures and pressures for land purposes in order to obtain better economy in operation, and people responsible for the development of ship propulsion machinery are also paying due attention to this question.

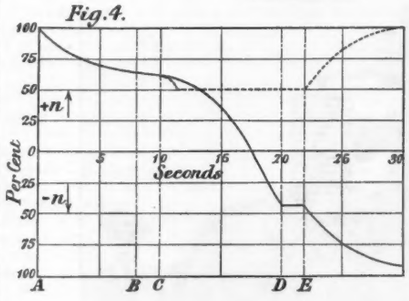
Every increase of 13 deg. F. in the superheating gives a reduction of 1 per cent. in the steam consumption, and consequently not less than about 15½ per cent. for 200 deg. F., and the gain in efficiency with increasing admission pressure is too well known to be more closely treated in this paper. The striving for higher economy has also led turbine designers more generally to increase the number of blade rows, i.e., to increase the length of the turbine. These factors all contribute to make the turbine more sensible to variations and stresses of the above-mentioned kind. It is, therefore, highly desirable that the marine turbine should be kept steadily running in one direction, special means being provided for the reversing action.

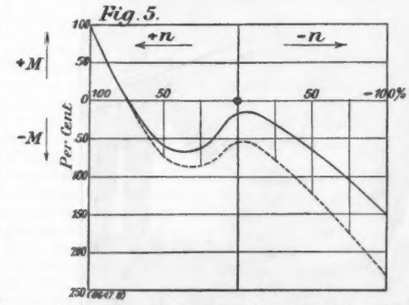
An interesting solution of the problem is represented by the electric transmission, which has been adopted for many ships of late design. This system allows for a convenient selection of the speed of propeller relative to that of the turbines. The most efficient propeller speed of an ordinary cargo vessel may be set at about 70 r.p.m., whereas the corresponding r.p.m. of the high-pressure turbine should not be lower than 4,000, if real economic operation results are aimed at. These figures give a transmission ratio of about 60 : 1, which, however, cannot be suitably obtained unless the electric transmission is combined with a mechanical gearing.











Another system is represented by the Föttinger hydraulic transformer which has been used in a few vessels. Here the steam turbine, in principle, drives one or two water pumps which supply hydraulic energy to a turbine connected up to the propeller shaft. When going astern the water is led to a reversing turbine on the same shaft, thus forcing the propeller to run in the opposite direction. The speed ratio of the Föttinger-transmission must be kept comparatively low. Figures above 5 : 1 are not advisable on account of the losses entailed in the transmission. Further reduction of the propeller speed should be made by combining the transformer with some mechanical gearing.

The losses in the electric drives as well as in the Föttinger transformer are considerable also when going ahead, which might be the reason why these systems have not been more generally adopted. The losses in the electric transmission can be set to 10 per cent. on an average, and the Föttinger transformer also shows about the same losses at a speed ratio of 5 : 1.

With these points in view the author designed an oil-operated reversing clutch in connection with a mechanical reduction gear, which will be briefly described below. Investigations as to the use of such a clutch were made as early as 1909, but, as at that time there was not much known about the design of gearings and friction clutches of similar sizes, the idea was not pursued until 1917. Further investigations during this year showed, however, that such an arrangement could be constructed with far smaller dimensions than expected, and that the losses when going ahead would be practically negligible.

It has been remarked as an argument against a direct reversing clutch that in designing internal-combustion engines for marine purposes a direct reverse without the usual reversing gear has been aimed at. As this, however, can be done without in any way affecting the efficiency of the motor simply by means of a suitable design of the valve gear, such a design naturally is preferable to a reversing clutch.

In principle, it might be considered that a reversing turbine is a special auxiliary motor coupled to the main motor for the purpose of going astern. When considering the astern turbine system from that point of view, this particular solution of the reversing problem does not appear very gratifying. It is much easier to construct a light and cheap reversing gear for a steam turbine than for a Diesel engine. The latter is generally coupled direct to the propeller shaft, whereas the former, except for high propeller speeds, as a rule drives the propeller through one or two reduction gears, allowing the reversing gear to be placed on one of the high speed shafts. In this way the torque will be reduced and dimensions and weight of the reversing gear will be considerably smaller.

The reversing clutch installations hitherto built have been designed in conjunction with turbines of radial flow double rotation type, although the design of the clutch allows for direct application on any usual marine turbine without material modifications.

In cases where a double reduction gear is used, the reversing clutch is to advantage applied on the intermediate shaft. The clutch consists of a fixed outer casing, in which is mounted a revolving gear case containing a set of gears wheel of the epicyclic type. The gear case revolves with the intermediate shaft when the propeller is working ahead, but remains fixed in the outer casing when going astern. These two conditions are obtained by means of two sets of disc clutches, one inner and one outer. The mutual positions of the outer discs are regulated by four pistons to which oil can be applied on either side.

The inner set of discs is pressed together by means of oil pressure on a single piston and released by means of a spiral spring. This spring, as well as the oil piston, is placed concentrically with the gear case and the shafting.

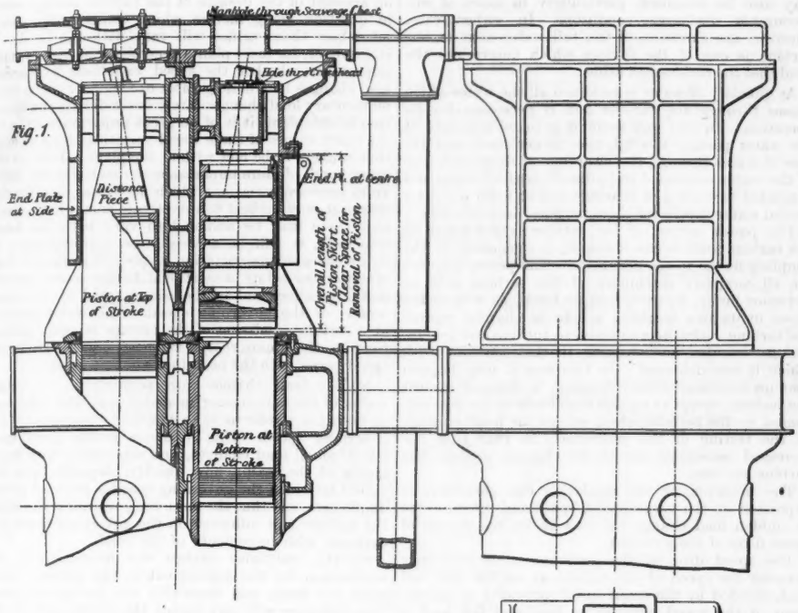
The access or escape of the oil to the pistons is regulated by means of a manœuvring wheel fitted up near to the stop valve. When going ahead (see Fig. 1) the outer discs are released and separated, and the inner disc set is under pressure, causing the gear case to be fixed both to the driving and driven parts of the intermediate shaft. In this condition the gear acts as a flywheel, the spur wheels inside the case remaining stationary relative to each other. The power is thus transmitted direct to the pinion of the second reduction gear.

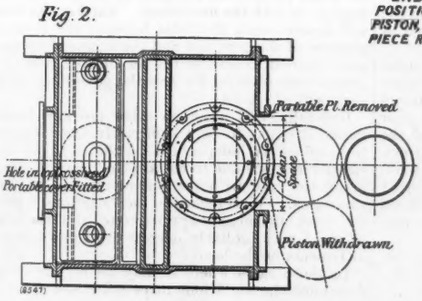
When going astern the inner discs are released and the outer ones are pressed together (see Fig. 2). The gear case then becomes fixed relative to the outer casing, and the spur wheels inside the gear case are forced to revolve in opposite direction, thus also reversing the motion of the main shafting with the propeller. If both disc clutches are released, the propeller shafting and the second reduction gear become stationary, and the gear case rotates idle at half the number of revolutions of the intermediate shaft (see Fig. 3).

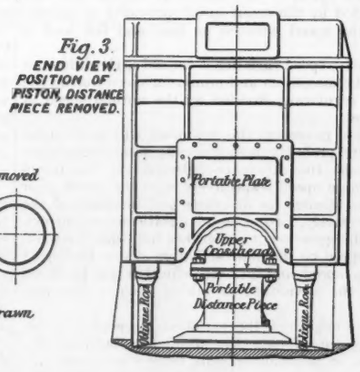
With this arrangement for reversing there is evidently no necessity for stopping the turbine when manœuvring, but provision is made for automatic reduction of the turbine speed to 50 per cent. of its normal value. During a change over of the manœuvring wheel, which is coupled up to the steam regulating valves, the steam is partially shut off, and the turbine speed will be correspondingly reduced. A diagram showing the alterations in the turbine speeds during a

*Paper, abridged, contributed to Section K of the World Power Conference, on July 10, 1924.

PALMERS' CAMELLAIRD-FULLAGAR ENGINE PISTON WITHDRAWAL SYSTEM.


Manhole through Scavenge Chest
Hole through Crosshead
Fig. 1.
End Plate at Side
Distance Piece
End Pl. at centre
Overall Length of Clear Space for Removal of Piston
Piston at Top of Stroke
Piston at Bottom of Stroke





change over is reproduced in Fig. 4. Fig. 5 shows proportional variations in the propeller torque during the change.

Three vessels fitted with this type of propulsion machinery are sailing under the Danish flag. The first clutch turbine was installed on the T.S. Pacific, of Copenhagen. At official tests the consumption of steam exclusive of auxiliaries proved to be 8·33 lb. per brake horse-power an hour, under the following conditions: Steam pressure at the stop valve, 185 lb. per square inch; temperature, 662 deg. F.; 2,097 b.h.p.

PALMERS' CAMELLAIRD-FULLAGAR OIL ENGINE.

ONE of the most important considerations in deciding the merits of any type of prime mover is the question of the accessibility for examination, removal or replacement of working parts, especially in the case of marine engines. In connection with the very large number of types of marine internal-combustion engines afloat to-day, little if any tendency can be marked towards the same degree of standardisation as set in many years ago with the triple expansion steam engine. In the movement towards this end, which must inevitably take place at an early date, the question of accessibility will rank as of prime importance.

There is no part which has more important functions in the oil engine than the piston and its packing rings. In many very highly developed designs the removal of the piston with its rings for examination is a leading motive in the design of the principal parts. In the case of the Camellaird-Fullagar engine constructed by Messrs. Palmers Shipbuilding and Iron Company, Jarrow, which was described in ENGINEERING on August 31, 1923, and the trial results of which were detailed in our issue of March 28, 1924, some criticism has been made on account of the work involved in the engine room in overhauling the pistons. Messrs. Palmers have designed an arrangement, illustrated on this page, to overcome any difficulty which might be experienced in this direction with the earlier designs as previously described, and an application for a patent has been filed. As the engine works on the two-stroke cycle principle the pistons have skirts to cover the exhaust and scavenging air ports in the cylinder liners. The procedure adopted for withdrawing pistons is as follows:—There is a manhole in the cover of the scavenging air pump above the square pistons which forms the top crossheads, to take the thrust of the oblique rod connecting the adjacent top and bottom pistons. A hole is cast in the centre of the top cross-head, which is fitted with a cover plate. Through the manhole in the scavenging pump and hole in the crosshead a sling can be attached to the top main piston. When the piston, which it is necessary to remove, is at the bottom of its stroke the distance piece between crosshead and piston skirt is taken away. The engine is then barred round so that the crosshead is at the very top, and the piston can then be lifted by the overhead gear by means of a band round it attached to roller and trolley beams, which are supported by the permanent part of the end plate, and then withdrawn through the portable section fitted in this plate. Fig. 1 shows the distance piece in place in the case of one piston, and removed from the other. After the top piston is removed the bottom piston can be similarly dealt with, if desired.

Although not shown in the illustration, arrangements have been made to cast rails on the top of the cylinders to enable a trolley, carrying the piston, to be readily removed through the opening made by the removal of the portable plate. Since larger openings are necessary for the withdrawal of the pistons necessitating larger square pistons in the scavenging pumps, it has now been found possible to dispense with the two centre pumps making four scavenging pumps in place of six. In the case of designs, where the scavenging air-pump is not fitted on top of the working cylinder, all that is required is the removal of the end plate, which is made of light steel. The seemingly small improvements, such as this modification, which are being constantly made to the various designs of oil engines, greatly enhances their-attractiveness as marine prime movers, and must advance an already fast-growing industry.

PROPOSAL FOR UNIFORM RULES FOR TESTING WATER-POWER PLANTS.*

By PROFESSOR G. SUNDBY (Norway).

THE guarantees provided for the delivery of water-power machinery are sometimes drawn up on rather deviating bases. This may easily lead to an unjust comparison of different contracts, or tenders, or at any rate render the comparison difficult. The guarantees may also often be drawn up in such a way that it is unnecessarily troublesome to carry out the testing of the plant. In order to minimise these drawbacks it would be of importance to adopt general, if possible, international rules for testing water-power plants and have them formulated in such a way that they are synonymous and permit of convenient methods of testing. Further, such rules should contribute to the encouragement of designs which utilise the natural energy in the most economical manner. I have considered it expedient to come forward with a proposal for rules for the testing of water-power plants. This proposal is generally consistent with a practice which has developed in Norway, although no definite rules have been established, wherefore deviations occur.

Before drawing up rules for the testing of a turbine it is expedient to determine what parts should be classed as forming an integral part of the same. As such, it seems natural and practical to include all the organs necessary to make the turbine a complete machine, which, in fulfilment of its purpose, transforms the energy of the water into mechanical work. If, for instance, we consider a Francis turbine in casing, it is at once apparent that the draught tube ought to be counted as part of the turbine, since, on the one hand, part of the transformation of the energy takes place in the same, and, on the other hand, the measuring of the mean quantity of energy contained in the water in a certain section of the draught tube is difficult and intricate. Correspondingly, the casing also ought to be included in the turbine, because an adequate design of the casing will further the proper utilisation of the energy, and practical difficulties will at once be met with on measurement, if one is to decide the quantity of energy at any point in the casing itself.

Nearly all modern turbines require a speed-regulating device, *i.e.*, a governor, since it is practically impossible to run the turbine without one. At any rate, the number of cases where the governor can be dispensed with is extremely small. It is, however, of small importance to the power plant to know how much power is spent on the operation of the organs of the governor. It is the performance of the installation as a whole which is of importance. And it is not correct to compare the efficiency of two turbines, merely by themselves, if the auxiliary machinery of the one consumes more power than that of the other. It is only by taking into account the total power consumption of all auxiliary machinery that the efficiency is ascertained, which forms the correct basis of comparison.

The efficiency test, if merely the output of the turbine itself is to be determined, is as a rule difficult to carry out in plants where each turbine drives its own governor pump, because it is always, at any rate with large turbines, risky to disconnect the governor. It is only in rare instances that the power consumed by a flywheel can be determined. Thus, it must be considered the most correct as well as the most expedient to class all necessary auxiliary machinery for the turbine as belonging to it.

The head ought to be determined in such a way as to express the quantity of energy at the disposal of the turbine per kilogramme of water, and in a general way the effective head H_e may be defined as the sum of the velocity head in a section of the inlet tube just before the turbine and the mean piezometric head in same section measured above the tail water at the draught tube. The velocity head is taken as velocity head of the mean velocity in said section of the inlet tube, $\frac{(Q/F)^2}{2g}$.

If the wheel is running clear of the tail water (as with turbines without draught tube or hydro-pneumatic action) the head is to be measured from the mean point of outlet from the runner. For turbines in open flume which as a rule are provided with draught tube,

* Paper, abridged, contributed to Section N of the World Power Conference on July 10, 1924.

the effective head is to be taken as the difference between the water levels in the wheel pit and the tail-race. In this case the entrance velocity is generally small, and the corresponding quantity of energy can only to a small extent be utilised by the turbine.

Losses of head in penstocks, valves, screens, gates, &c., should not be charged against the turbine. This, on the other hand, must be done with the hydraulic losses of head in the casing and draught tube, both being designed in direct connection with the turbine, and being able to influence to a great extent the economic utilisation of the water.

By far the greatest number of turbines supplied from a pipe are provided with gate valves, allowing the turbine to be drained without emptying the pipe-line. It might be natural to consider this gate valve as belonging to the turbine. For practical reasons, however, I have decided not to do so. On measuring the piezometric head in the inlet tube it is necessary to use a comparatively small hole in the wall of the pipe to obtain a correct result of the measurement, and before starting the tests it should be possible to make sure that the hole is not choked up. Accordingly, this opening should be located behind the gate valve, *i.e.*, on the down-stream side of it, otherwise it would be necessary to empty the whole pipeline. Provision for gauging of the piezometric head ought certainly to be arranged for during the construction of the turbine in the workshops. It does, however, often happen that it has to be done on site, it then being more practical to drill a hole behind the valve than in front of it, especially in cases where two, or more, turbines are connected to the same pipe. It may only in a few cases be possible to measure the piezometric head at a straight portion of pipe of sufficient length, and it should then, in order that a reliable mean be obtained, be measured in two, or four, places on the circumference of the pipe.

In defining the effective head, the deduction of the velocity head at the discharge from the turbine (for instance at the outlet from the draught tube), might be considered, as there must necessarily be some dynamic energy in the water for it to get away at all from the turbine. This reasoning may in itself be right enough, but, on the other hand, it is of interest to keep this velocity head as low as possible, and if one turbine in this respect is more favourable than another, this also ought to appear in the efficiency.

The matter will appear still more unreasonable, if, as in the German rules, a deduction in the effective head is to be made for the velocity head in the tail-race, something being hereby introduced which has nothing to do with the turbine to be tested. For instance, let us take a turbine, the draught tube of which discharges into a tailrace, common to several turbines, at a slight angle to the direction of the tail-race flow. According to the German rules, the head shall then diminish with the velocity head in the tail-race flow, computed for the discharge of all turbines. Consequently, the greater this discharge, the smaller the computed effective head would be, this in spite of the fact that the effective head of the turbine in question in reality should increase with an increasing tail-race flow, the latter to some extent causing the pressure in the draught tube to decrease. This rule is impractical also on account of the necessity of determining separately the velocity in the tailrace.

This way of reasoning might generally appear somewhat more correct, if the "normal" velocity head, instead of the actual velocity head, in the tailrace during the test were introduced. In several cases, however, this quantity may appear somewhat arbitrary, unless it be chosen to make the velocity head zero, or in other words to neglect the quantity of energy corresponding to the discharge velocity from the turbine. In this way a plain, clear and unequivocal rule is obtained, a rule which on the whole will certainly be more correct than one which takes this velocity head into account.

In the case of impulse turbines with the wheel running clear of the tail water, it will be, practically speaking, impossible to take into account the energy on account of the residual velocity at the outlet. With these turbines, therefore, the question eliminates itself, and analogical rules for both kinds of turbines are obtained by using the proposed way of figuring.

In the case of impulse turbines equipped with draught tube there is always a loss of head on account of the wheel having to run in air. The size of this loss may vary according to the different designs of the turbines, the loss being dependent on the more or less adequate devices for the introduction of air into the draught tube. It will, therefore, be correct to give an expression of this in the efficiency of the turbine, as is the case if the head be defined as above set forth.

In this connection it should be mentioned that the elevation of the tail water may to a certain extent vary beyond the point where the discharge of the draught tube takes place. For instance, if the sectional area of the tailrace expands from the place of discharge of the draught tube onwards, the level of the water will rise a little. This, however, is a matter which has nothing to do with the turbine, or its design, and should not be taken into account on determination of the head at the disposal of the turbine. The opposite may also be imagined, particularly in cases of unfavourable discharge conditions. In either case, however, the elevation of the tail water next to the turbine is one of the factors which determines the head that the turbine can utilise.

As quantity of water is reckoned all the water which passes through the turbine and is necessary for its operation. In this way account is taken not only of the water passing through the runner itself and the loss of water through the clearance of same, but also of the water consumed in hydraulic sealing boxes and expended in cooling of bearings and so forth (unless a special water supply for these purposes be available).

The power output of the turbine is measured on the turbine shaft where it ceases, *i.e.*, generally at the coupling flange to the generator. The power required for all auxiliary machinery of the turbine such as governor pump, flywheel and so forth, as well as the losses in its own bearings, are to be charged against the turbine. Bearings common to turbine and generator are counted as belonging to that machine with which it was delivered. In this way it may happen that no resistance of any bearings be charged against the turbine, except as regards such loads on the bearings caused by the turbine, which exceed the loads existing at the testing of the generator. In that case the increased resistance should be charged against the turbine on test.

The precision of the regulation can generally be expressed by the variations in speed and pressure due to sudden load changes as well as by the degree of speed drop of the governor.

The speed drop of the governor is the difference between the speed of the turbine at no load and full load, divided by the mean speed (provided no adjustment of the speed between no load and full load is made).

The relative speed variation is defined as the difference between the maximum and minimum speed during the period of regulation, divided by the normal speed of the turbine.

With good governors this definition will be identical with the one probably most generally used, which takes into account the difference between the maximum and minimum speed respectively, and the speed prior to the load change for decreases and increases of the load respectively. In cases of unsatisfactory adjustment of the governor it sometimes happens, however, that the speed on the first oscillation swings back past the original speed, and thus the definition here proposed possesses the advantage of taking such a case into account.

By some engineers, the variation in speed is determined by introducing the difference between the maximum or minimum speeds respectively, and the speed corresponding to the new load condition. This method has the disadvantage of not showing the actual speed variation, since it is necessary to take the speed drop of the governor into account to find it. Besides, it does not take into consideration the case before mentioned of the speed oscillating past the initial one.

The value of the speed variation measured will depend on the speed prior to the load change. For this reason care should be taken to keep the latter as close as possible to the normal speed of the turbine. This condition is of little or no importance, however, with modern governors having a small speed drop. (If for some reason or another the normal speed prior to the load change cannot be reached by adjustment, a closer approach to correctness can be achieved by multiplication of the ascertained speed variation by the ratio of the speed prior to the load change to the normal speed of the turbine.)

The relative pressure variation is defined as the difference between the highest and lowest hydraulic pressure head, respectively, during the period of regulation and the pressure head at no load, divided by the head at no load. When it is proposed to figure the variation of the pressure in relation to the head at no load, instead of the effective head of the loaded turbine, this has the practical advantage that the head at no load is easy to observe, since, in order to determine it, the velocity head in the inlet tube may be neglected.

Generally, it will not be possible to carry out the tests at one and the same head, and the result of the observations, therefore, ought to be recomputed for a definite head, the quantity of water and the speed varying proportionally to the square root of the head, and the horse-power proportionally to the square root of the third power of the head.

The values obtained from the governor tests, on the other hand, cannot be recomputed according to any general law. The speed drop, however, can be determined by adjusting, for the head at disposal, the gate opening and the position of the governor in such a way that they correspond to the full horse-power at normal head, and then observing the speed at full load.

On the other hand, to refigure the variations in speed and pressure on sudden change of load is not so easy on account of the designs of the turbine and governor in question being factors which concurrently determine how these values will vary with the head. It is, however, for most plants generally a matter of small importance whether the speed variations by sudden load changes be a little greater or smaller; since large momentary load changes rarely occur during the operation of the plant, it is of no great importance to know the exact values of these speed variations for any head that is likely to be met with at the plant. It is, on the other hand, of more importance to determine the maximum pressure variations which may arise, and for this reason it may be best to investigate somewhat closely how these may be assumed to vary with the head. Generally, it will be a very close approximation to figure the pressure variation, expressed in metres head of water, as being proportional to the water velocity in the pipeline, and to the piston speed of the servomotor, or the governing speed. The water velocity at a certain admission of the turbine is again proportional to the square root of the heat, and the governing speed varies with the head for two main reasons.

(*a*) The load change corresponding to a certain travel of the servomotor increases with the head, and so does the stroke of the slide, and consequently the governing speed. This influence makes itself most felt at small load changes, and diminishes with increments of the load; how quickly, depends upon the extent to which the governing speed is reduced by the diaphragm, and thus the more the governor is throttled, the quicker this influence on the governing speed will decrease with increments of the load.

(*b*) The resistance against the movement of the mechanism for the adjustment of the gateage varies with the head, and therewith the governing speed. This influence will vary during the stroke, and for the two directions of movement, depending upon whether the water pressure on the parts of the gateage is acting against, or with the movement. Further, the influence will depend upon the ratio between the accumulator pressure of the governor and the excess of piston pressure required to actuate the servomotor, and thus the greater this ratio is, the less the governing speed will vary with the head.

Generally, and when no other previous agreement exists, it ought to be a sufficiently exact assumption to consider as independent of the head all relative speed variations due to certain load changes, the same being the case with the maximum relative pressure variations. (With regard to the variations in pressure, the above may often be approximate, while the variation in speed may probably decrease to some extent with increments of the head.)

In those cases where it may be of importance to determine the variations in pressure and speed under another head than that available during the testing of the plant, the method of recomputing should be agreed upon in advance, the special conditions of the plant and the special designs of turbines and governors to be tested being taken into consideration.

The degree of precision to be obtained at the testing of a water power plant will, to a great extent, depend upon how favourable are the conditions for taking the measurement and, of course, on the care in effecting it, as well as on the instruments used. Therefore, in general rules it is not reasonable to establish a fixed tolerance to allow for errors of measurement. It is, however, quite important, for instance, on comparison of tenders, to have a fixed rule for the establishment of the tolerance. As matters stand at present, one firm may claim 1 per cent. tolerance, another 2 per cent., and a third may be claiming 2 per cent. tolerance and also the payment of a certain fine for every additional (limited to two or three) per cent. that the actual test results may fall short of the guarantees. To the purchaser who has to view a decreased efficiency in relation to the whole plant, such a fine is a matter of very small importance, and the purchaser ought to consider the effective guarantee which may easily range from 1 per cent. to 4 per cent. or 5 per cent. below the nominal. Under these conditions the comparison of tenders may easily become somewhat arbitrary, and it seems to be most natural and desirable to adopt the practice of the contractors entering into their guarantees without any kind of tolerance, in other words, of beforehand reducing their guarantees with the margin found necessary considering the test methods, also decided upon beforehand for the case in question.

In case the test should show results below the guarantee in one respect, a corresponding excess in another ought to a certain extent be allowed to make up for the deficiency. As the conditions relative to this question may be widely different for the various plants, it should be decided upon beforehand as to the extent

100-GALLON TRAILER FIRE PUMP AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. GWYNNES ENGINEERING COMPANY, LIMITED, ENGINEERS, LONDON.

Fig. 1.

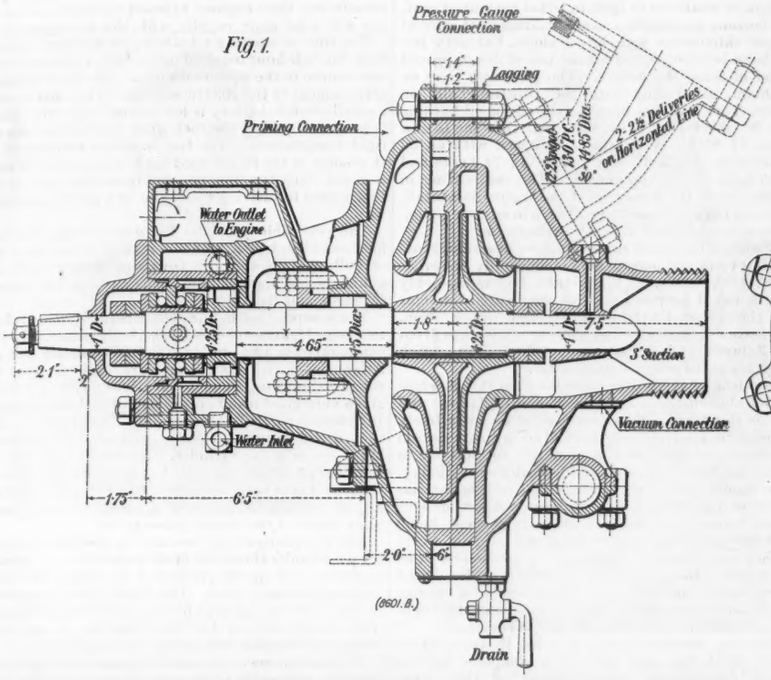
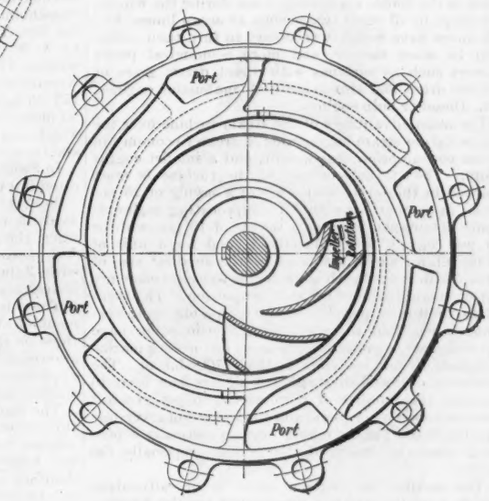


Fig. 2. VIEW OF DRIVING SIDE.



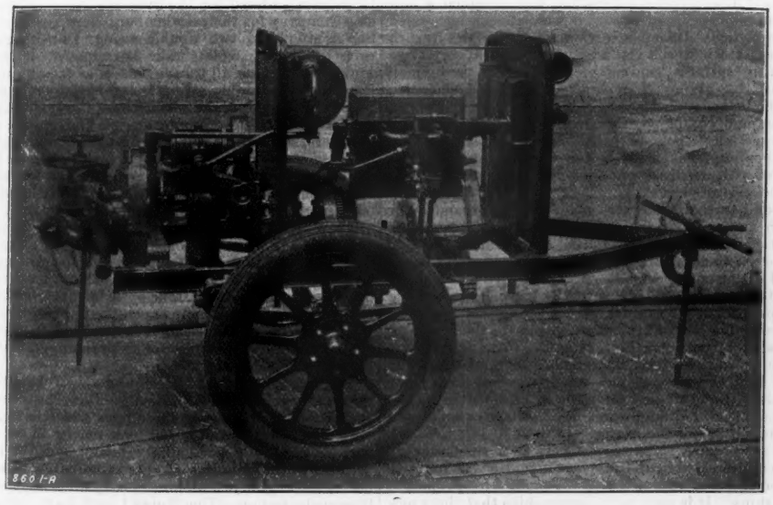


FIG. 3.

100-GALLON TRAILER FIRE PUMP.

THE advantages for many conditions of a light and easily-handled fire-fighting unit has led to the development by a number of firms of the appliance now known as the trailer fire pump. As its name implies, this pump is not mounted on a self-propelled vehicle, but, with the object of cutting down weight, so that it can be run over rough ground and manhandled into awkward positions, it is mounted on two wheels only and adapted for hauling as a rule behind an ordinary motor car or other vehicle.

One of the firms which has produced a singularly attractive little unit of this type is Messrs. Gwynnes Engineering Company, Limited, of Hammersmith, W.6. This pump is illustrated in Figs. 1 to 3 annexed, the first two illustrations showing details of the two-stage pump, while the third is a view of the machine itself. The latter figure, however, does not do justice to the complete appliance in the way of general appearance, as the casing has been removed for the purpose of more clearly showing the features of construction. The complete unit is very neatly finished, and its smart appearance would be creditable to any fire-fighting organisation.

The unit consists of an "Invincible" fire pump mounted with an 8/20-h.p. Gwynne petrol engine and gear box on a steel channel frame carried by two rubber-tyred wheels fitted with long laminated springs. The whole outfit weighs only 8 cwts., so that it may be easily handled over rough ground. The pump is capable of delivering 100 gallons of water per minute from one or two jets simultaneously, and of throwing to a height of 130 ft. with a single jet. It will draw from a depth of 18 ft. As a fire stream when throwing vertically the effective height is 80 ft. and horizontally the distance is 70 ft. The engine is a four-cylinder unit with detachable heads and overhead valves. It develops 14 h.p. at 1,800 r.p.m. The priming of the pump is arranged for by means of an exhauster driven from the spindle. Only a few seconds are required to get the pump to draw, after which the exhauster is cut out. The running costs are low, since the engine will run for 3½ hours on the maximum tank capacity of 4½ gallons of fuel. The storage space required is a length of 7 ft. 4 in., width of 4 ft. 1 in. and height 3 ft. 10 in.

The wheels are readily detachable for replacement if necessary. The frame is brought in at the front, where a cross bar is provided and an eye for attaching to a drawhook on the tractor. A hinged leg is also provided to steady the unit when working. The outfit is provided with the necessary suction hose, which is accommodated in forks fixed to the framing. The suction connection for the pump is 3 in. and the two deliveries 2½ in. This little appliance is to be seen at the stand of Gwynnes Engineering Company, Limited, at the British Empire Exhibition.

The same pattern of pump is fitted by Messrs. Gwynnes to a self-propelled light two-seater chassis having an 8-h.p. engine. In this case two gear boxes are provided, one for travelling and one for pumping.

such compensation should be allowed, and at what ratio between the different performances it should be carried out, for instance, a high efficiency at certain heads or loads, &c., being of more importance than under other conditions.

As a rule, the efficiency is guaranteed for full load and for certain fractions of the same. If at the test the power capacity of the turbine proves greater than specified, the efficiency should still be determined in proportion to the capacity specified, not in proportion to the one obtained, unless another method of procedure be especially decided upon in the contract, or buyer as well as supplier agree upon such procedure.

In connection with this proposal concerning rules for the testing of water-power plants, it may be as well to point out the advisability of introducing a fixed definition of the conception of "gateage" of a turbine whereby this term would get a meaning closely corresponding to the point of cut-off of a steam engine.

It is often convenient to have the performance of a turbine determined for certain fixed gateages, for instance in cases where the efficiency at a certain gateage varies with the head. It is not satisfactory to introduce directly the gate opening of a Francis turbine, or the travel of the needle of a Pelton turbine, as these quantities, on account of various constructive features, have no direct bearing upon the hydraulic qualities of the turbine. On the other hand, it seems natural, as far as a Pelton turbine is concerned, to base the definition on the diameter of the jet, or the area of the same, but these quantities are not directly known. It is to the same purpose, however, and gives a more general rule to base the definition upon the water consumption of the turbine and to define as: "gateage l," the position of the gates, or needle, corresponding to the full output, or the total water consumption at the head agreed upon, and as "gateage k," the position of the gates, or needle, corresponding to a water consumption of k times the total water consumption at the same head. Consequently, k may then assume values ranging from 0 to 1, or a little above, since it is generally possible to move the gate mechanism somewhat past l.

If such a definition of the gateage of turbines be introduced, it is reasonable for the efficiency guarantees to be drawn up in relation to the gateage, and this will especially be natural where guarantees are stipulated for different heads.

POWER FOR SHIP PROPULSION.*

By H. G. HAMMAR (Sweden).

THE old well-known reciprocating steam engine with cylindrical boilers of 120 to 200 lb. pressure is still holding its own in ships for inland waterways, coasters and Baltic traders. Owners specify these engines also in larger ships employed in the North Sea and Mediterranean trades, if they intend to navigate them in the Baltic ice coming home during the winter. For ships in all other trades such as ocean liners, &c., the owers have found it necessary to turn their attention to more modern and more economical prime movers such as turbines with direct drive, gears or electric drive, and also to internal-combustion engines, viz., Diesel or bulb engines.

The main advantages of the steam turbine over the reciprocating steam engine are: a greater economy in steam consumption, less weight, and a smaller engine room. The steam economy of the turbine is most marked in the larger units, where a saving of 25 per cent., in comparison with the reciprocating engine, is easily attainable, whereas a saving of 15 per cent. or 10 per cent. will be considered good for a unit of 1,000 b.h.p., which seems to be the smallest size of unit in which it is worth while trying to secure economy out of steam turbines for ship propulsion. The theoretical limit is supposed to be 500 b.h.p., but considerations other than those of steam consumption have led designers to prefer reciprocating engines for marine installations of less power than 700 b.h.p. The tendency of Swedish turbine designers has been to increase the number of revolutions, to get greatest possible economy of steam and good power of reversing. The upper limit of the revolutions is practically dependent upon the design of the gearing, especially the pinion.

The smaller engine-room space is an advantage which is of the greatest importance for the Swedish shipowner, as it leaves more room for transporting the bulky commodities of Sweden such as timber, paper pulp and paper, and also imported articles such as cotton, wool, grain, &c. Swedish designers have tried to utilise the smaller consumption of steam in the turbine by reducing the size of boilers and bunker space so as to leave the greatest possible part of the ship's hold to cargo space, but we have to note a few instances where they have gone too far, with the result that the boilers have not been able to generate sufficient steam for the engines when the ship has had to work its way in a rough sea.

Ljungström uses a mechanical gear instead of electric drive. The latest reports from ships with the new design seem satisfactory. The reports on coal consumption vary very much; I have seen bad reports and also very favourable ones embodying, in fact, record figures, which, if verified, will confirm the Ljungström turbine as the most economical of all turbines. It is hard to explain the causes of the varying results, but it is very likely that carelessness and ignorance on the part of the engine-room staffs account for a considerable proportion of the bad results.

The designers of the other Swedish steam turbine, the de Laval, have been using mechanical gearing all the time from the very first turbine made in the year 1890. This turbine has principally been used for power plants on land only. The first ship installation was fitted in the year 1912. The de Laval's have from this date delivered a great many ship installations, which have all proved very satisfactory, thanks to the great experience the designers of this engine have gained during a period of more than 30 years in the construction and machining the gearing for this turbine.

The reports of coal consumption for ships with this turbine are as a rule very good. I would refer to the owners' reports on the ss. Forsvik, a small cargo steamer of 1,800 tons d.w., 235 ft. by 37 ft. by 17 ft. 6 in., fitted with a de Laval turbine of 650 b.h.p., the smallest turbine made for ship propulsion. The aggregate of five voyages with full load gives an average sustained sea speed of 9·55 knots with a coal consumption of 11·35 tons ordinary bunker coal per day.

The most notable installation made by the de Laval is that in the ss. Drottningholm, a passenger liner running between New York and Gothenburg for the Sverige-America Line. The dimensions of the boat are 520 ft. by 60 ft. by 41 ft. 2 in. displacement 19,130 tons. She had direct coupled turbines of 250 revolutions, constructed in 1903, which were taken out and replaced by a de Laval turbine of 10,000 brake horse-power geared down to 200 revolutions. Two boilers were taken out at the same time, thus reducing the number of boilers from nine to seven, and the total heating surface from 31,000 F^2 to 24,000 F^2. Firing was changed from coal to oil burning. The result is that the ship, which in the year before the change made an average speed from port to port of 13·93 knots with a coal consumption of 213·1 tons of coal per day, the year after the change made a corresponding average speed of 16·16 knots with an oil consumption of 96·98 tons a day. The turbines with gearing have now been in hard service for two years without showing any signs of weakness or fault in either turbine or gear.

Oil burning is attracting a certain amount of interest amongst shipowners with larger ships, but very few ships have been converted for the use of this improved method of firing the boilers. The passenger liner ss. Stockholm, alternating with the Drottningholm on the New York line, has been converted for oil burning by A. B. Götaverken, with the result that she is now making 14·95 knots sustained sea speed with an oil consumption of 103·67 tons against 13·74 knots and 153·65 tons of coal previously. The real saving in oil firing lies in the reduction of the engine-room staff, which was reduced from 72 to 31 men in ss. Stockholm, and from 96 to 35 men in ss. Drottningholm.

In Swedish merchant ships steam is, as a rule, generated in cylindrical marine boilers, generally known as "the Scotch boiler." Water-tube boilers are only used for naval purposes and for very special designs where the saving of weight is a very first consideration. A shipowner in the Baltic has had one of his ships fitted with Babcock and Wilcox water-tube boilers, which have given satisfactory results so far.

There is a marked divergence between the development of stationary steam generator installations and those on shipboard. Space and weight are more freely allowed for in land installations, and accordingly certain appliances generally used in these are not suitable in ships where they will be found too heavy or too bulky.

The economiser or gas-heated feed-water heater has thus several times been introduced in connection with marine boilers, but without ultimate success, being too heavy and too cumbersome for marine work. Another well-known appliance to economise fuel consumption, the gas-heated air-preheater, has found a very wide application in connection with marine boilers, and especially is this the case with the well-known Howden forced-draught air-preheater.

Following the same direction as Mr. Howden, whose pioneer work has met with such complete success, Fredrik Ljungström, chief engineer of the Aktiebolaget Ljungströms Angturbin, has designed a new improved type of air-heater, in which he has succeeded in applying well-known regenerative principles in such a way that it works continuously and with very large heating surfaces concentrated within a very small space, thus giving the apparatus a very high efficiency, which makes it able to regain the waste heat in the flue gases more completely than has been practically, if not theoretically, possible until now. Götaverken, in Gothenburg, has made a first installation on shipboard with one of these new air-preheaters, which seems to be a great success.

Comparative tests were made on the steamer Bur with and without the air-preheater. The tests were carried through in the Baltic, the steamer running between Sundsvall and the Kiel Canal, and show a fuel saving of 15 per cent. According to a report made by the owners, still better results have been achieved in practice after the damper in the funnel had been altered to a good fit, preventing some of the hot gases passing by the air-heater, as seems to have been the case during the trial run. The owners also pointed out that the steamer met rough weather during the trials with the air-preheater and had a smooth seaway, when natural draught was used, which was to the disadvantage of the heater.

The Swedish shipowner is not, as a rule, so very much interested in all these new inventions to improve upon the economy of the steam engines for propelling his ships. It is only in the larger ships that these new designs are used to their full advantage, but for this class of ships there is an entirely new prime mover, which has proved itself superior to the steam engine, especially on account of the reduced fuel consumption, which has so many great advantages from the owner's point of view and makes the whole ship more economical in running costs. I refer to internal-combustion engines, which have attracted the interest of the Swedish shipowner to a greater extent than anything else. He has had an early and very satisfactory experience in this class of engines for 30 years or more. The "hot bulb" engine has been used for fishing boats and small coasters in Sweden since last century, and holds its own to-day among this class of craft. "Bulb engines" are not made for large power plants. I do not know of anybody in this country who has designed a hot bulb engine of more than 120 brake horse-power per cylinder, which, with six cylinders, will give some 700 horse-power as maximum, and I should say that 500 brake horse-power is to-day the economical limit.

The constructors of this engine have not lately come forward with new and revolutionary designs. Their endeavours are concentrated upon the perfection of mechanical details, quicker starting arrangements and easier running. Water-injection, which has given excellent results in the laboratory, has been abandoned for use at sea, where it was introduced a few years ago with high expectations of success. Saving in fuel has not been found to compensate for the added cost of carrying fresh water. Water-injection has also shown tendencies to increase the corrosion of the engine, and owners say that engines exposed to hard service at sea will wear more rapidly with this arrangement.

The time of starting a bulb engine has been reduced from the half-hour required in the first engines to about one minute in the modern designs. The most common arrangement is the electric starter. The current from a small electric battery is led through a glower, which is used for igniting the fuel, until the bulb attains its right temperature. The fuel injection is arranged so that some of the fuel is used for heating the bulb until it is hot, then the injection is adjusted so that all the fuel is used for driving the engine in a more economical way.

The reversible propeller for manœuvring the boat has been abandoned. The best makers and constructors of bulb engines are now using compressed air in the cylinders for manœuvring, *i.e.*, working the engines forwards and backwards.

The compression in the cylinders for ignition is kept to about 15 atmospheres in the bulb engine. In two comparatively new designs, the Elwe motor and the Atlas Diesel, both high pressure bulb engines, the compression is forced up to 25 atmospheres, which has given very good results in respect of fuel consumption. In Sweden we call these engines "Semi-Diesel" and they are designed for power units up to 250 brake horse-power in one cylinder. No engine of this size is running in actual service, but experiments tend to show that it is very likely that this will turn out to be a good serviceable motor at a cheap price for power units below 1,000 brake horse-power.

The Diesel engine has become the dominating engine for power units above 500 brake horse-power. Swedish engineers took up the problem of developing the Diesel engine at an early date. The Nobel Diesel motor may be said to be the pioneer for successful ship propulsion with Diesel engines, for ships running on the Neva, Volga and Caspian Sea system of navigation.

The most noteworthy motorship now building for the Swedish mercantile marine is the passenger liner M.S. Gripsholm, ordered for the Swedish-American Steamship Company for their Gothenburg-New York service. She is to have two double-acting Diesel engines, each developing 6,000 brake horse-power or 12,000 brake horse-power all told. This is, as far as I know, the first large double-acting Diesel engine ordered for propulsion of ships, and seems to be a very great step forward. The high reputation of the engine constructors, Burmeister and Wain, guarantees the success of this new enterprise. Careful experiments have been made with engines of this size and construction, which have in all respects satisfied the expectations of the constructors and the requirements of the owners.

The Swedish constructors of Diesel engines are using two-cycle as well as four-cycle motors. The shipyards which are building Diesel engines in their own works, *e.g.*, Götaverken, Eriksberg and Kockum, have taken up the construction of four-cycle engines, although these are heavier and more expensive to build than the two-cycle type. The reason is that the owners demand the greatest possible safety for ships running to distant or trans-oceanic ports.

Two firms, the Atlas Diesel and the Nobel Diesel, build two-cycle engines. The Atlas Diesel have several ships running with two-cycle engines, which have given very satisfactory results, but as a matter of fact the engines are built particularly heavy and the mean pressure in the cylinders is kept exceedingly low, which makes the engine just about as heavy and costly as the four-cycle engine. The Nobel-Diesel have just had one 1,600 brake horse-power engine installed in a tanker of 5,000 tons deadweight built at Götaverken. The trial trips are to take place within a few weeks. Judging from the large experience these constructors have had, the results are expected to be satisfactory. The engines are of a light but solid construction, and, of course, very much similar to the Continental two-cycle Diesel engine. The principal difference is that they do not work with supercharging of air in the cylinders.

* Paper, abridged, contributed to Section K of the World Power Conference, July, 1924.

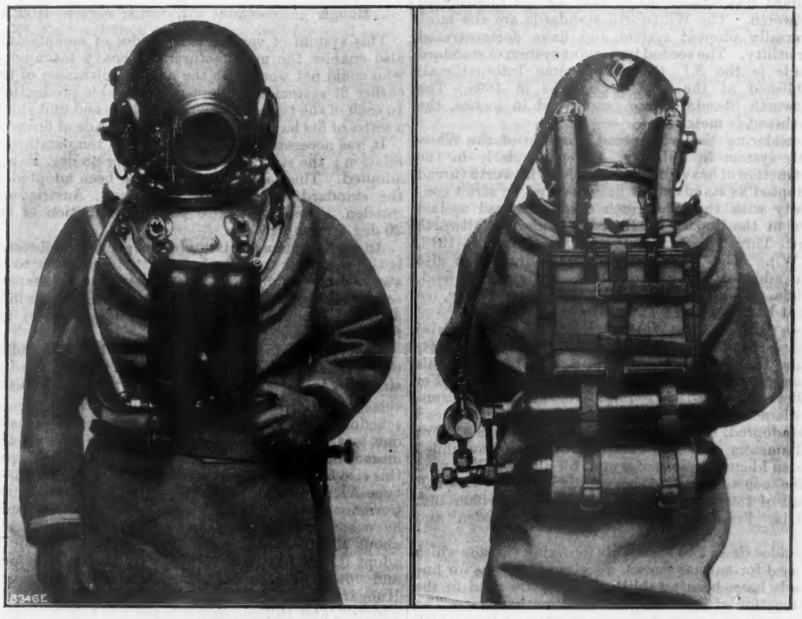
HARLAND AND WOLFF, LIMITED.—Messrs. Harland and Wolff, Limited, have issued an album giving particulars of the marine Diesel engines built by them. These machines, together with a large number of motorships of their construction, are illustrated. Views of the firm's works and yards are also included.

PERSONAL.—Messrs. Bostock and Bramley, whose new address is Dewsbury-road, Leeds, state that the rapid expansion of their business of power transmission engineering and the development of important American interests have led to changes in their organisation. Capt. Bramley-Moore will now reside in the United States, to effect a closer working with Messrs. Joshua Buckton and Company, Limited, with whom they are in association.

RESPIRATOR AND SELF-CONTAINED DIVING APPARATUS; EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. SIEBE, GORMAN AND CO., LIMITED, ENGINEERS, LONDON.

FIG. 1. RESPIRATOR FOR USE IN NOXIOUS GASES.



FIGS. 2 AND 3. SELF-CONTAINED DIVING APPARATUS: FRONT AND BACK VIEWS.

RESPIRATOR AND SELF-CONTAINED DIVING APPARATUS.

ONE useful feature which has followed the employment of lethal gases in the late war has been a marked improvement in the means available for protecting workers against the effects of such gases which may be liberated by accident in industrial processes, and for enabling men to enter chambers containing noxious gases or vapours for the purpose of carrying out inspections or effecting repairs. Messrs. Siebe, Gorman and Co., Limited, 187, Westminster Bridge-road, S.E. 1, have specialised in the production of respirators for this class of work, and their exhibit at the British Empire Exhibition includes a number of examples, one of which we illustrate in Fig. 1, above. The respirators, to which the trade name "Puretha" has been applied, are made in various forms, all of which involve the use of an absorbent material to remove the noxious element from the atmosphere before it reaches the lungs of the user. The chemical nature of the absorbent is, of course, selected to suit the particular element against which protection is required. The details of the apparatus are also affected by the degree of protection it is necessary to provide for the wearer's face.

In the respirator illustrated, the face piece, or mask, is made of thick rubber and covered with an elastic textile fabric. The shape of the mask is such that the surface of contact between it and the face of the wearer is a maximum and the internal air space is reduced to a minimum, this arrangement having been found greatly to increase the comfort of the user. The face piece is held in position by a head pad, fitted with a harness composed of elastic bands, the lengths of which are readily adjustable. Eyepieces, formed of non-splinterable glass, are provided, and the deposition of moisture on them is prevented by means of ducts, which deliver the colder inspired air on to the inner surfaces of the glasses as it enters the apparatus. Before entering, the air passes through purifying chemicals contained in a canister carried by the wearer as shown in our illustration; the pocket on the right of the illustration is provided to hold the mask when not in use. The purifier is connected to the mask by means of a short length of special corrugated non-kinkable rubber tubing. The expired air passes out to the atmosphere through a quick-acting, non-return valve situated close to the wearer's mouth as shown in Fig. 1. No mouthpieces or nose clips are employed in the respirator illustrated —a circumstance which further increases the wearer's comfort. The purifiers can, however, be supplied without a face mask if desired, and a nose clip and mouthpiece must then be used. The life of the canisters, of course, depends upon the nature and degree of contamination of the atmosphere in which they are employed, but when exhausted they can be readily replaced by a new one. They can be supplied to give protection against any gas, vapour or fume, and also against dust or clouds of ultra-microscopic particles.

Another of Messrs. Siebe, Gorman's exhibits is a self-contained diving dress for use under water in difficult situations, where it would be impossible to employ an ordinary diving dress to which air is supplied by a pump. The self-contained apparatus, which we illustrate in Figs. 2 and 3, can be used at depths up to about 65 ft. of water. It is arranged similarly to that of the "Proto" mine-rescue apparatus described on page 807 of the preceding volume; thus the wearer breathes the same air several times over, the exhaled carbon dioxide being chemically absorbed and the requisite oxygen being supplied from two steel cylinders. The latter contain 20 cubic feet of a mixture of air and oxygen in equal parts, compressed to a pressure of 120 atmospheres, and they are carried on the back of the diver, as shown in Fig. 3. They are connected to the helmet through a reducing valve and an emergency by-pass valve, shown on the left of Fig. 3. A further supply of mixed air and oxygen is provided in the weight worn on the chest of the diver, the weight containing two cylinders each holding 2½ cubic feet compressed to the above-mentioned pressure.

The carbon dioxide absorbent is carried in a metal chamber lined with vulcanised rubber, and strapped to the diver's back as shown in Fig. 3. The absorbent chamber, it will be seen, is connected to the back of the helmet by two flexible tubes, and through one of these tubes the expired air is delivered to the chamber from a mouthpiece worn by the diver. The air, from which the carbon dioxide has been absorbed, returns through the other flexible tube to the helmet and is breathed again by the diver, together with the added oxygen supplied to the helmet from the cylinders. Breathing is performed entirely by the mouth, the nose being closed by a clip provided for the purpose, and the mouthpiece, above referred to, is fitted with both inspiratory and expiratory valves, to prevent the expired air from being inspired again until it has passed through the carbon-dioxide absorbent. The oxygen-air mixture is delivered to the helmet at the rate of 5 litres per minute, and the supply is sufficient for about two hours' working. It should be mentioned, however, that the oxygen mixture in the smaller cylinders is intended as a reserve and is only used to enable the diver to reach the surface in the event of the larger cylinders becoming exhausted. In these circumstances, the diver turns on the small valve, seen on the left of Fig. 2, from time to time, and thus supplies oxygen to his helmet through the tube shown in the illustration.

A full equipment of ordinary diving apparatus, including dresses, helmets, pumps, telephones, submarine lamps, &c., is, it may be added, shown by Messrs. Siebe Gorman and Co., and their exhibit includes a large diving tank, with glass windows, in which demonstrations are given from time to time.

STANDARDISATION IN GERMANY.*

By DR. F. NEUHAUS.

SYSTEMATIC standardisation in Germany dates back to the spring of 1917, when the leading engineering firms formed in co-operation with scientists an Engineering Standards Committee. The work of this Committee very soon overstepped the limits of engineering, and invaded nearly all branches of industry. The consequence was that in December, 1917, the Standards Committee of the German Industry (N.D.I.) was established.

The constitution of the N.D.I. is based on the principle that German standards should be developed by co-operation of manufacturers, consumers and scientists. It is understood that the N.D.I. should establish fundamental standards for all branches, and should be responsible for conformity of the standards established for the several branches by special committees with the general standards and with each other. All suggested standards for the German industry are examined at the Inspection Department of the N.D.I. and are published in the Official Journal of the N.D.I., the "N.D.I.-Mitteilungen," for criticism. Suggested special standards are published in the technical journals of the branch to which they appertain. Objections are carefully investigated and the suggestions which have been corrected in accordance with such objections, unless the objections are such as to require the complete remodelling of the suggested standards, are laid before the Board of the N.D.I. which causes the standards to be incorporated in the schedule of standards. Only after a standard has been so incorporated is the standard schedule passed for publication and general use.

The entire German industry co-operates with the N.D.I. Funds for the N.D.I. are found by selling the standard schedules and by contributions of comparatively small amounts on the part of the industry. No Government subsidy is given. A schedule of the standards that are final, and of those that are being prepared, is issued every quarter, so as to indicate the progress of standardisation.

Obviously, it is not possible to discuss all details within the limits of this paper. Only the work of establishing fundamental standards will be described in detail, while the several operations of special standardisation will only be briefly referred to.

German industrial standards comprise three groups: fundamental standards, dimensional standards, and standards concerning material.

Fundamental standards are those which are found

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in all branches of engineering and must, therefore, be considered when establishing all other standards. Among the most important fundamental standards are thread standards. Long before the time of standard committees, standardisation of threads was attempted in the several industrial countries. The first thread standard was established in 1841 by the Englishman Whitworth. The Whitworth standards are the most universally adopted system and have demonstrated their utility. The second important system of standard threads is the S.I. thread (Système International) established at the Zurich Congress in 1898. The Whitworth Standards are established in inches, the S.I. thread is metric.

Considering the widespread adoption of the Whitworth system in industry, and particularly in the construction of heavy machinery, the Whitworth thread is adopted as standard for fixing screws, in strict conformity with the Whitworth original thread as laid down in the Report on British Standard Whitworth Screw Threads, June, 1919 (B.E.S.A. 92—1919, B.S.W.). The Whitworth original thread has also been adopted in Switzerland, Belgium, England, Austria, Hungary, Holland, Sweden and Italy, so that it has become an International standard.

As a parallel to the Whitworth standard, there is also a metric standard, which was established for diameters within the range of between 6 and 68 mm.; this system is identical with the S.I. system of 1898. For smaller diameters, as required for fine mechanisms, the diameters and pitches of the Loewenherz thread were adopted, but with a thread angle of 60 deg. For all diameters above 68 mm., the system is continued with an identical pitch of 6 mm. for all diameters used in the construction of heavy machinery. The S.I. thread of 1898 was adopted in Germany, Switzerland, Austria, France, Hungary, Holland, Sweden and Italy.

Besides these two standards for fixing threads which are used for normal screws, a series of systems for fine threads have been established which are used in the construction of machinery and fine mechanisms. The Whitworth pipe thread may be mentioned here which also conforms exactly to the English original given in the Report on Standard Pipe Threads for Iron and Steel Pipes and Tubes, May 1918 (B.E.S.A. 21—1909), which is also adopted in Switzerland, Austria, Holland, Sweden and Italy.

As to the application of the two systems, we may say that the entire German industry will adopt the metric thread for diameters up to and including 10 mm. ($\frac{3}{8}$ in.), as in that range the pitches of the Whitworth thread are too coarse in relation to diameter, and the screws have a tendency to work loose in operation. For similar reasons, the metric thread is preferred above 2 in. diameter, so that the range of the Whitworth thread is $\frac{1}{4}$ in. to 2 in. But even in this range, two big branches of industry, machine tools and motor-cars, use metric threads exclusively, and the adoption of the metric system in other branches is steadily progressing.

Another fundamental standard for the mass production of interchangeable standardised parts and for interchangeable production manufacture generally are "fits," *i.e.*, the establishing of tolerances and allowances. These standards are of extreme importance. Before standardisation, two fundamentally different systems had been adopted in Germany, the system of unit bore, in which the bore is identical for all fits and the variations in fits are in the shaft and the system of unit shaft, in which the shaft is identical for all fits while the bores vary.

Obviously, it was desirable to establish one system of fits only for the entire industry, and probably there is no other question which was so thoroughly discussed. The result was that each system has such considerable advantages for some branches of industry that neither could be abandoned without decisive drawbacks.

A fundamental difference of the fits adopted in the D.I.N. standards, as compared to other systems adopted before standardisation, is the position of the "zero line," *i.e.*, line of the nominal size. These older systems were established on the bi-lateral principle as a rule, that is, the zero line was the symmetry line of the bore tolerance in the unit bore system and the symmetry line of the shaft tolerance in the unit shaft system. In the D.I.N. standards, the zero line is the lower limiting line of the bore tolerance in the unit bore system, and the upper limiting line in the unit shaft system. This is called the uni-lateral system. The advantage of this system is that parts may be exchanged notwithstanding variations in the amount of tolerances. This position of the zero line has been adopted by the standards committees of other countries, viz., Switzerland, Austria, Holland and America, and for British standards this system has recently been considered.

The German system of fits is based on a uniform scale of tolerances and allowances which is given by the formula

$$PE = \frac{1}{200}\sqrt[3]{D}$$

where D is the diameter in millimetres and PE one fit unit.

There are four degrees of exactitude, as follows:—

Extra fine, tolerance equal to	....	....	....	1 PE
Fine	,,	,,	....	1·5 PE
Plain	,,	,,	....	3 PE
Rough	,,	,,	....	10 PE

This system of various exactitudes of manufacture also enables the manufacturers of heavy machinery, who could not work with the narrow tolerances of the earlier fit systems, to adopt exchangeable production. In each of the two fit systems, unit bore and unit shaft, a series of fits have been fixed for each grade of fineness.

It was necessary to adopt a standard temperature of relation; the standard of 20 deg. C. or 68 deg. F. was adopted. This temperature has also been adopted as the standard in Switzerland, Holland, Austria and Sweden. The U.S.A. also plan the adoption of the 20 deg. C. temperature.

Another fundamental standard of general importance is the standard size of schedules. Its object is to do away with the numerous variations in size and shape of commercial papers, printed matter, journals, drawings, &c. The standardisation of sizes is based on the following considerations:—

Every size is to be obtained by halving or doubling the next larger and smaller size respectively. Also all sizes are to be similar. It follows that the ratio of sides in every size must be $1 : \sqrt{2}$. The fundamental schedule is 841 by 1,189 millimetres, its area being one square metre. This area unit of the metric measuring system is designated by A0. By halving this size four times, the business letter size is obtained, type A4, size 210 by 297 mm. This is the size of the German standard schedules. Numerous companies have adopted this size for their correspondence and about fifty leading technical journals are about to adopt it. It has been accepted by the German mail and other authorities. In Switzerland, Austria-Hungary and Tchechoslovakia, the size has been adopted, and Holland and Sweden will follow shortly. Besides the A series, three intermediate series have been established on the same principle, which will be used for envelopes, files, raw material, &c.

Preferred numbers are also very important, that is, geometrical progressions by 5, 10, 20 and 40 units. By means of these progressions, standards may be established having a uniform increase per step, and they are a basis for the logical establishing of all dimension standards. Preferred numbers have been very useful not only for general purposes, but particularly when fixing numbers of revolutions of pulleys, pressure stages of pipe lines, performances and some dimensions of electrical machinery, &c. Preferred numbers are also an excellent means for agreement on the base of logical rules, if otherwise in consequence of differences in opinion an agreement on a uniform basis cannot be attained.

A fundamental tool standard is the taper for holders of drills and milling cutters. For these metric tapers 4 and 6, and in connection, Morse tapers 0 to 6 and, following these, metric tapers 80, 100, 120 and 140 will be used. Standardisation of tools comprises all tools for machining metals, particularly twist drills, broaches, taps and dies, milling cutters and measuring appliances.

It is obvious that parts of machinery will occupy a considerable space in standardisation of dimensions. Of prime importance are screws, for which more than 150 standard schedules have been elaborated and completed. Sizes of jaws were standardised in conformity with American standards, but dimensions were fixed in full millimetres. The same jaw standards were adopted by Switzerland, Austria, Holland and Sweden.

Other parts of machinery which have been standardised are rivets, pins, bearing sleeves, oil grooves, set collars, gears, keys and keyways, hand wheels and crank handles, handles, wire ropes, &c. Instead of 307 cross sections before standardisation, 49 cross sections were considered sufficient after standardisation.

A number of special standards have been elaborated in co-operation with the interested industries. An international agreement has already been arrived at for ball bearings by the countries which are most concerned with the manufacture of such bearings, America, Sweden and Germany. Negotiations, which extended over a period of several years, were brought to a preliminary close in Berlin in October, 1923. As international proposals, standards of radial ball bearings have been published for a range of diameters from 4 to 450 mm. In Germany, these standards have been adopted for diameters up to 110 mm. In January, 1924, proposals for international standards of thrust ball bearings were published in the "N.D.I.-Mitteilungen," and proposals for standards of combined radial and thrust bearings will follow shortly. These publications are being made in conformity with the Zurich agreements of 1923.

Numerous draft proposals for pipeline and fittings standards have been published, and will probably be issued this year. The feature of this standardisation is the establishing of standard pressure stages by means of the preferred numbers already referred to. One pressure stage for steam and the next higher one for water are established for the same dimensions of the piping, the lower stage applying in the case of steam, gases and dangerous liquids, the higher one in the case of water and non-dangerous liquids. Standards for gas piping have been established in conformity with English standards, the cylindrical thread previously used having been cancelled on the suggestion of the Pipe Committee, only threads having a taper of 1:16 being adopted.

In the standardisation of flanges, the tendency was to stick to the bolt circle diameters of 1882 and 1900, but in some cases corrections were necessary in order to obtain a logical system. The alterations could be made without difficulty, since it is known that the old standards differ from those used abroad. The preferred numbers of screws are divisible by four, so as to be able to use four-spindle drilling machines and to enable fittings to be secured in vertical and horizontal position.

Gas and water fittings, steam fittings, heating fittings and appliances for measuring pressure and heat, have been standardised. The principal feature of this work is the standardisation of lengths and assembling dimensions, the dimensions of parts being only standardised where it is expected that parts from several manufacturers will frequently have to mate.

In transmission parts, standards for shaft diameters, couplings, bearings, pulleys, gears, &c., have been elaborated. The number of normal shaft diameters was reduced from 29 to 18 by standardisation, thus reducing considerably the number of patterns for accessories and spare parts to be kept in stock. In the standardisation of transmission parts as well as in that of pipelines, the principal feature are assembling dimensions.

Mention may be made of special standards for autogenous welding, fire extinction, lifting tackle and cinematograph apparatus, and the work of the Association of German Machine Tool Manufacturers, whose most important standards are threads for the ends of lathe spindles and fixtures for milling machines.

Special committees have been appointed for the following branches, which committees work independently but put their standards before the N.D.I. for final and uniform consideration and publication.

Buildings.—Standards for technical police regulations, standard dimensions for bricks, timber and roof parts, windows and doors, staircases, canalisation, road building, iron structures and bridges, equipment for portable railways, &c.

Electrotechnics.—Standards for pressure and intensity stages, Edison threads, raw materials, insulating materials, telephony, machines and transformers, electricity meters, cables and accessories, &c.

Motor Cars.—Standards for screws, gauges and tools, parts of engines, sparking plugs, parts of chassis, tyres, rims, &c.

Locomotives.—Thorough standardisation of practically all parts.

Railway Rolling-stock.—Fundamental standards for mass production of interchangeable parts of cars, including tolerances for many dimensions which are important for assembly.

A special committee will consider standardisation in mining, and another will again take up standardisation of agricultural machinery.

The third group of standards, standardisation of materials, comprises three divisions, viz.:—Testing of materials; iron and steel; non-ferrous metals.

In testing materials, symbols and definitions and general rules for testing matarials by tensile, Brinell and technological tests are being standardised.

Standardisation for iron and steel—recently any wrought iron manufactured in liquid condition and without further treatment has been called "steel"—comprises standardisation of properties, strength and analysis, and of dimensions of rolled and drawn products, such as plates, tubes and sections and the exactitude of manufacture thereof.

Similarly, with non-ferrous metals, the properties of the several metals, such as copper, zinc, tin, aluminium, nickel and their alloys, on the one hand, and dimensions and tolerances for stock made from such metals, plate, tubes, bars and wire, on the other hand, are standardised.

Contrary to other countries, standardisation of materials has not been developed in Germany to the same extent as standardisation of dimensions. The reason for this is that in Germany this matter has been regulated to a great extent by the authorities, and that the standardisation of materials on account of the opposing interest of producer and consumer is much more difficult than standardisation of dimensions. Work on the standardisation of materials, however,

has made considerable progress, and it is to be expected that more than seventy standards will be ready for publication in a short time.

The N.D.I. had published 631 standard schedules up to April 1, 1924, 203 having been elaborated by special committees, while about 510 proposals are being prepared.

THE PROTECTION OF UNDERGROUND WATER SUPPLY.

A PAPER on this subject was read at the Annual General Meeting of the British Waterworks Association held recently at Sheffield, the author being Mr. A. B. Cathcart, M.Inst.C.E., waterworks engineer to the Brighton Corporation.

He stated that, as a general principle, waters derived from underground sources were less liable to pollution than moorland waters collected from streams and impounded in open reservoirs, but the latter had the additional safeguard of being filtered before distribution, which was not general in the case of the former. Waters flowing in known and defined channels upon the surface were already protected against pollution more or less satisfactory by the general law, and did not come within the scope of the author's remarks, but he desires to call attention to the necessity for extending similar protection to underground water. Supplies derived from deep wells were liable to pollution from the moment the rain fell upon the outcrop of the stratum. The most prevalent, and undoubtedly the most serious danger to such supplies, however, was contamination which might take place after the rainfall had percolated into the subterranean storage formed by the water-bearing rock, and it was particularly to the necessity for protection at this stage that the author proposed to confine his remarks.

Liability to pollution after percolation varied with different geological formations, and depended to a great extent upon the lithological characteristics of the rock, and the configuration of the outcrop. Rocks such as the sandstones of the Triassic formation, which were of considerable thickness, close-grained, homogeneous and comparatively free from joints, acted as a natural filter. The possibility of surface contamination in such formations, percolating to the depth from which supplies were usually pumped, was fairly remote, and danger needed therefore only to be apprehended in the vicinity of faults which communicated with the surface. Waters derived from the limestones, the Hastings, Ashdown and Tunbridge Wells sands, and the Greensand, were less immune on account of the prevalent folding and jointing of these rocks and the presence of fissures, and waters derived from the chalk, with which the author is at present principally concerned, were, in his opinion, more exposed to contamination than all other underground waters. In this formation the possibility of pollution was an ever-present danger.

The upper chalk, which was the principal water-bearing section of the formation, was in itself very compact, but usually, and particularly at high elevations, was scantily covered with soil and traversed with fissures frequently of considerable width and extending to great depths. These fissures acted as the natural channels through which the rainfall which had percolated into the pores of the chalk passed through the stratum, and as such fissures not infrequently communicated with swallow holes upon the surface, pollution was readily conducted into the lower parts of the formation. Where, as in the London basin, the chalk was overlaid by a more recent and impervious formation such as the clay, the danger of pollution at the wells as a result of contamination which had taken place upon the outcrop many miles away was very remote, by reason of the fact that purification took place to a large extent as a natural process in percolating so great a distance. The present reference to the dangers which beset chalk waters, therefore, applied to cases where, as in the South Downs, wells were sunk in the exposed outcrop.

The most vital factors affecting the relative risks of pollution in the author's opinion were the density of population upon the outcrop, and the question of whether the district was sewered or unsewered. In cases where the outcrop was purely agricultural—an ideal condition seldom realised in connection with deep-well supplies—the only danger which needed to be apprehended was that arising from pig-styes, cattle-sheds, &c., and an occasional cesspit. Unfortunately in the more general circumstances of the present time, the outcrop of the water-bearing strata, and the neighbourhood of the wells, were more or less populated, and a watchful eye had constantly to be kept upon the graver and ever-present danger of sewage pollution. As an instance of this, the Brighton Corporation derived its supply from deep wells in the upper chalk formation of the South Downs. Four of the five pumping stations were in rural and unsewered areas, and although when the works were put down the surrounding downland was very thinly populated, the subsequent growth of the borough and of the adjacent towns had gradually brought the populated area nearer the wells, and the possibility of sewage pollution was one which could not now be disregarded. At the Patcham pumping station a very serious situation had arisen—so serious in fact that upon a report which the author recently presented to the corporation, they had at once resolved to promote a Bill in Parliament to obtain powers for safeguarding the supply.

Mr. Cathcart then dwelt on the need for legal modifications to safeguard the nation's water supply as a whole. He pointed out that under existing legislation great risk attended any attempt to secure protection against pollution, the onus of proof of contamination remaining with the water authorities. A solution could be found, he thought, along the lines of actual presence of free impurities on the water site surface being accepted as proof of contamination taking place.

CATALOGUES.

Air Ejector.—A two-stage, steam-operated air ejector, made either with or without an inter-cooler, is fully described in a catalogue received from the Metropolitan Vickers Electrical Company, Limited, Trafford-park, Manchester.

Electrical Fuses, &c.—A descriptive catalogue and priced lists of "Ventex" fuse units, ironclad cut-outs, and ironclad distribution boards, are to hand from Switch-gear and Electrical Productions, Limited, Ellis-street, Birmingham.

Time-Limit Relays.—The Swedish General Electric Company, Limited, 5, Chancery-lane, London, W.C., have issued a catalogue describing their single-pole, overload, time-limit relays of the induction type for connection to current transformers.

Chemical Apparatus.—A further list of stills, autoclaves, heaters, pans and other chemical vessels has been received from Messrs. W. J. Fraser and Company, Limited, Dagenham, Essex, who make a variety of special plant for chemical manufacturers.

Voltmeter.—The Cambridge Instrument Company, Limited, 45, Grosvenor-place, London, S.W., have sent us an illustration of their thermionic voltmeter for measuring the strength of wireless signals, determining losses in insulators, measuring stray magnetic fluxes, &c.

Steel Vessels.—Illustrations of 15 different examples of steel-plate work, including air receivers, vulcanisers, jacketed vessels, factory chimneys, rag boilers, railway sleepers, &c., have been received from the Leeds & Bradford Boiler Company, Limited, Stanningley, Yorks.

Electric Motors.—We have received from Messrs. Brittain's Electric Motor Company, 110, Cannon-street, London, E.C.4, a catalogue of their alternating-current motors, giving particulars and prices for single-phase and polyphase types, and of suitable starters and switches.

Lifting Appliances.—A catalogue of lifting and carrying appliances, giving illustrations, dimensions and prices for a very extensive variety of types, is to hand from Messrs. Herbert Morris, Limited, Loughborough, who have also sent a circular relating to their vertical boilers made for outputs of from one to twenty nominal horse-power.

Rail Welding.—The welding of rails by the aluminothermic process is fully described in a catalogue received from Thermit, Limited, 155, Church-road, Battersea, London, S.W. The catalogue includes sections on the welding of rails of high-carbon steel, a repair process for making good worn parts of tracks, rail grinding, and welding conductor rails.

Steam Fittings.—Several types of steam fittings and instruments are illustrated in a catalogue received from the Steam Fittings Company, Limited, West Drayton, Middlesex, and a short and clear explanation of the application and action of each is also given. This catalogue is worth filing for reference wherever steam power or heating are in use.

Steam Road Rollers.—Messrs. Marshall, Sons and Co., Limited, Gainsborough, have sent us a copy of their new catalogue of road rollers, which are made in weights ranging from five tons to twenty tons, with single-cylinder or compound steam engines. All parts are made to interchangeable gauges and are of the best material and workmanship, which are essential for economical service.

Hydraulic Propeller.—A very full account of the hydraulic propeller invented by Mr. D. V. Hotchkiss is given in a new catalogue issued by the Hotchkiss Hydraulic Propeller Company, Limited, 26, Martin-lane, London, E.C.4. The catalogue also contains particulars of many small craft, both commercial and pleasure, in which this propeller has been successfully applied.

Pressure Gauges.—Messrs. S. A. Daniel, Limited, Edward-street Parade, Birmingham, have sent us a copy of a new issue of their catalogue of pressure gauges and fittings, with a list of prices. The gauges are made with all the usual scales and include gauges indicating both vacuum and pressure, the hand moving in either direction from the zero corresponding to atmospheric pressure.

Clutches.—Messrs. Thomas Broadbent and Sons, Limited, Huddersfield, have issued a special catalogue of their Benn friction clutch, which is adaptable as a shaft coupling or for connection to a pulley or driving wheel. This clutch is suitable for high or low powers transmitted at high or low speeds, and is made in a great range of sizes of which dimension tables are given and prices are stated.

Wire Ropes.—The economical application of steel wire ropes in winding and haulage is dealt with technically by Mr. T. Albert Taylor in a paper which has been published by Messrs. John and Edwin Wright, Limited, Birmingham, who are manufacturers of wire and fibre ropes. The matter is clear and practical, and will repay the attention of engineers responsible for selecting ropes suitable for various duties.

Electrical Instruments.—Messrs. Siemens Brothers and Co., Ltd., Woolwich, have sent us three recently issued catalogues describing electric mine shaft signalling visual indicators, a pyrometer for measuring the temperature of the exhaust gases of internal-combustion engines in order to detect inefficient conditions, and electrical distant reading thermometers suitable for measuring the temperature of cold stores, steam, feed-water, &c.

Pulveriser.—A catalogue received from Messrs. Vickers and International Combustion Engineering Company, Limited, Africa House, Kingsway, London, W.C.2, describes the Raymond pulveriser for grinding various materials, including coal. The pulveriser is a vertical mill in which the rollers run on the inside surface of a ring and the ground material is removed by an air current. The machines are made at Barrow-in-Furness.

Pressed Steel.—The increasing use of die-pressed steel is indicated by a large catalogue received from Messrs. Joseph Sankey and Sons, Limited, Wellington, Shropshire, which contains six sections dealing with wheels for motor-cars and other vehicles, panels, mudguards, &c. chassis frames, axle cases, brake drums, foundry ladles, barrow bodies, steel barrels, parts for railway work, shipbuilding and general engineering, furniture and storage bins.

Cranes.—Messrs. Henry J. Coles, Limited, Derby, have issued a catalogue of jib cranes, including a very wide range of capacities up to 25 tons, mainly with steam drive, but also electrically-driven. The cranes are usually mounted on rail wheels, and, when required, are self-propelling, so that they can be used for shunting work, stacking timber, &c. Petrol-electric cranes, a steam navvy and grabs are also illustrated in the catalogue.

Cranes.—Illustrations of a number of electric overhead travelling cranes are given in a catalogue received from the Anderson-Grice Company, Limited, Carnoustie, as examples of the work carried out by this firm. The list of standard sizes includes nine lifting capacities ranging from two tons to thirty tons and mentions the speeds of hoisting, cross traverse, and travelling for each. The text contains some material for consideration in ordering cranes of this kind.

Wood-working Machinery.—A bench type of universal wood-working machine, adaptable for sawing, boiing, moulding and other similar work, is described in a catalogue received from the De Walt Manufacturing Company, Bridgeton, New Jersey, U.S.A. An electric motor, provided with means for attaching the various tools, is suspended by a yoke from a radial arm pivoted on a hoisting pillar. The yoke allows the tools to be swivelled for working at an angle.

Steel Piling.—A further catalogue of steel sheet piling of joist section has come to hand from the British Steel Piling Company, Limited, 54a, Parliament-street, London, S.W.1. The joints are made either by locking pieces which connect the flanges of two adjacent piles or by shaping the flanges themselves for interlocking. The piling is supplied on hire, with the option of purchase, or sold subject to return after use at an agreed price. Machinery for driving and drawing the piles is also described.

Aerial Ropeways.—An excellent description of apparatus for conveying material in sacks, buckets, &c., by means of aerial ropeways, is given in a catalogue, issued by Main Ropeways, Limited, 47, Victoria-street, London, S.W.1, who are designers of, and contractors for, the necessary plant. This is, in some cases, almost the only way, and, in many cases, the most economical way of conveying material from mines, quarries, &c., over uneven ground to a loading point in the regular land or water transport system.

Electrical Machinery.—A set of catalogues issued for the British Empire Exhibition by the Brush Electrical Engineering Company, Limited, Loughborough, deals with turbo-generators, condensers and ejectors, transformers, alternators, frequency changers, and liquid starters. These catalogues contain general descriptive matter and illustrations of the various plant units, and another catalogue, relating to coal costs, gives calculations of the saving effected by the low fuel consumption of the 5,000-kw. Brush-Ljüngstrom turbo-generator.

Electrical Machinery.—The general catalogue, extending to over 100 pages octavo, issued by Messrs. Campbell and Isherwood, Limited, Raleigh-street, Bootle, Liverpool, contains particulars of steam-driven electric generating sets, and of electrically-driven winches, hoists, ash hoists, saw benches, fans, &c. The catalogue also deals with a great variety of land and marine electric light fittings, cables, switches, fuses, and accessories for power and light, reduction gears with paper pinions, and portable electric drilling machines and accessories. The matter is carefully compiled and arranged, and the printing excellent, but the addition of a contents and general index would greatly facilitate reference.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

211,942. C. A. Brown, South Farnborough. Shutter Radiator Controllers. (18 *Figs.*) November 28, 1922.—The invention relates to improvements in radiators for water-cooled engines on aircraft and other vehicles of the type wherein the cooling effect is regulated as required by means of hinged shutter devices for controlling the air flow through the radiator core or tube block. According to the invention, a radiator for a water-cooled engine is fitted with hinged shutters of substantially triangular or trapezoidal form or having converging sides which are situate at different peripheral positions around the radiator fore and aft axis for controlling the air flow through the radiator core or tube block for regulating the cooling effect, and which, when closed together, present a continuous or approximately continuous converging or tapering deflecting surface from back to front of the shutter arrangement and allow the air to flow past in an approximately or more or less streamline path, at the front or the back of the radiator core or tube block, so that the aerodynamic resistance of the radiator is reduced and when opened apart do not offer any material resistance to the free

Fig. 1.

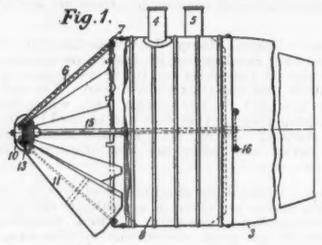


Fig. 2.

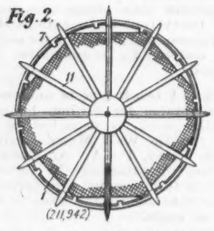
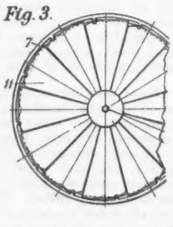


Fig. 3.

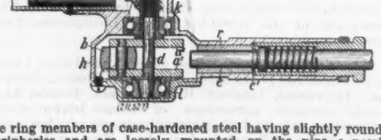


(211,942)

passage of the cooling air through the radiator core or tube block. 1 indicates the radiator core tube or block, 2 a fore extension consisting of adjustable air-flow control means, and 3 an aft extension consisting of a fixed streamline fairing. 4 and 5 are the water inlet and water outlet respectively to and from the radiator casing. The front extension 2 consists of a number of equi-spaced converging spindles or rods 6 which are connected to a foundation ring 7 on the radiator casing 8 and to a central boss 10. On the spindles 6 are pivotally-mounted shutters 11 consisting of thin metal casings of tapering formation with bearings at each end. The shutters are operated by means of a central bevel wheel 13 which gears with a number of segmental bevel pinions 14 rigidly attached to the shutters. The bevel wheel 13 is keyed on a central shaft 15 which has a fore bearing on the boss 10 and passes along the central axis of the tube block 1 and at its aft end is adapted to be turned by a crank 16. The shutters may be arranged with their adjacent edges approximately abutting when closed or may overlap. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

211,527. G. H. Thompson, Bournville, Birmingham. Percussion Tools. (2 *Figs.*) June 25, 1923.—The invention refers particularly to percussion tools of the type in which a rotating member or cage carries one or more weights having limited movement in a radial direction, the weights flying outwards under centrifugal force and imparting impulses to a slidably mounted tool holder of which the inner end is arranged in the path of the weights. The cage for the weights is formed by two discs *a*1, *a*2 secured upon the spindle *d*. The weights *b*



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are ring members of case-hardened steel having slightly rounded peripheries and are loosely mounted on the pins *c* passing through the discs. The spindle *d* is carried on three ball bearings *j*, *k*, *l*. Mounted on the spindle is a bevel wheel *o* in mesh with a bevel wheel *p* on a spindle *q* to the outer end of which a flexible shaft from a source of power is connected. The anvil member *e* is slidably mounted in a bush *r* in an extension of the casing *h*, and has at its outer end a head *e*1 which engages the outer end of the bush and prevents the member *e* from moving so far inwardly as to foul the rotating cage. (*Sealed.*)

211,939. A. E. Cooper, Stafford, and C. Jones, Lower Broughton, Manchester. Notching and Punching Presses. (5 *Figs.*) November 28, 1922.—According to the improvements, the notching press is provided with two plungers arranged with the overhanging head parts extending in diametrically opposite directions. The two plungers are operated through gear wheels and cranks from a power shaft common to both. *a*, *a* are the two plungers, each with an overhead tool-carrying part *a*1 and arranged back to back. *b* is the guide common to both plungers, the top end of the guide extending upwards to a point above the plunger when in their highest position. Each plunger is supported by a spring *c* suspended by a cover *d* bridging the top ends of the guide *b*. The plungers at their lower ends are connected to the power shafts *e*, *e* by eccentrics *f* and links *g*. To facilitate the stopping of either plunger while the other plunger continues to reciprocate, a clutch is introduced between the plunger and the connecting pin *i* of the links *g*. This clutch consists of a rect-

Fig. 1.

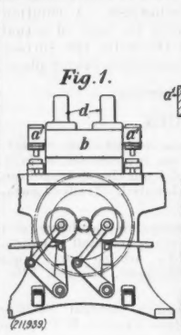
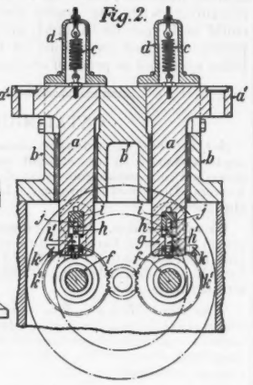


Fig. 2.



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angular swivel block *h* arranged in a space below the connecting pin *i* and adapted to swivel to a position parallel with the axis of the pin or to a position at right angles to such axis. In the plunger is an elongated recess *j* which with the block *h* lying parallel with the axis of the pin *i*, allows the pin and links to move up and down without affecting the plunger, which at such time is held in its highest position by the spring *c*. On swivelling the block *h* to a position across the recess *j* the up-and-down movements of the pin and links are imparted to the plunger. The block *h* is swivelled by means of a spindle *h*1 provided at its lower end with a spur pinion *h*2 engaging a rack *k*, slidably mounted in the plunger and projecting beyond the side of the plunger, where it is adapted to contact with a movable stop *k*1 on the machine frame, said stop being moved into and out of the path of the end of the rack by hand, and the end of the rack being bevelled to cause it (the rack) to move inwards on meeting the stop, while a spring returns the rack to its normal position after leaving the stop. (*Sealed.*)

MOTOR ROAD VEHICLES.

211,582. C. K. Edwards, Chingford, London, and The Associated Equipment Company, Limited, Westminster, London. Transport Vehicles. (3 *Figs.*) November 24, 1922.—The invention relates to transport vehicles of the type in which tractor and trailer parts are employed, the load of the latter being partly supported upon the rear of the former. According to a feature of the invention, a transport vehicle of the type described, wherein the load from the trailer is received by the tractor upon supports at each side of the vehicle extending down to the rear axle of the tractor, is characterised in that the supports, which are connected to the rear axle at points situated outside the frame of the tractor and immediately adjacent to the rear wheels thereof, and which include resilient members, are employed to constitute also the connection between the rear end of the tractor chassis and the rear axle of the tractor. The rear axle of the tractor is shown at 10 and a corresponding

Fig. 1.

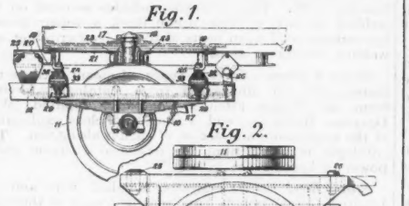
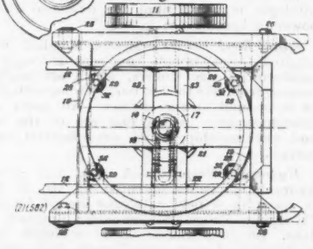


Fig. 2.



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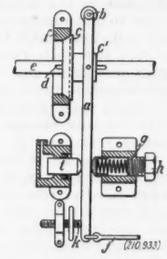
road wheel at 11. The tractor chassis longitudinals are shown at 12 and a portion of the trailer chassis at 13. The turntable includes a centre pin 16 upon which is received a bush 17 on the trailer, these two parts being secured together when the vehicle parts are coupled, by a spring-controlled U-shaped bolt 18 which can be withdrawn into inoperative position when it is desired to uncouple the vehicle parts. The turntable is composed of girders 19 arranged in plan in the form of a rectangle whereof two of the sides are parallel to the longitudinal centre line of the vehicle. The girders 19 carry on their upper surfaces plates 20, 21 and 22 and are also braced by cross girders 23. At the centre of the rectangle the pin 16 is situated. The rectangle is supported at each of its corners by brackets 25 and links 26, upon the end of leaf-springs 27 secured to axle 10. These springs 27 are situated outside the chassis member 12, immediately adjacent the wheels 11. The turntable framework also carries four angle brackets 28, which each receive the upper end of a depending link. Carried by the rear ends of the longitudinals 12 are other angle brackets 29, one of which reaches under each of the brackets 28. The brackets 29 are each perforated to permit the passage through them of a rod forming part of the depending link. Each rod controls a pair of opposed volute springs 32 and 33, which encircle it. The spring 32 bears at opposite ends against the brackets 28 and 29, while the spring 33 bears against the bracket 29 and against a washer towards the lower end of the rod. From the foregoing it will be seen that the chassis longitudinals of the tractor are supported on the axle 10 by way of the depending links, turntable, and finally the springs 27, while the forward end of the trailer is supported upon the axle 10 by way of the turntable and the springs 27. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

210,933. R. A. Blakeborough, London, and G. H. Reed Brighouse. Operating Bulkhead Doors. (1 *Fig.*) December 19, 1922.—In apparatus for operating vertically sliding bulkhead doors on ships in which the doors are normally actuated by hydraulic pressure, the door is provided with a frictional surface adapted to be engaged by a co-operating movable surface which is acted upon in one direction by a spring sufficiently strong to cause the frictional surfaces to engage with enough force to sustain the weight of the door, and in the other direction by a hydraulic ram which, when in operation, will exert sufficient force to overcome the spring referred to. Failure of the hydraulic system, therefore, will permit the spring to operate to hold up the door, if the latter be in the open position when the failure occurs. *a* represents a lever mounted at one end on a fixed pivot *b*. The lever *a* is non-rotatably connected to the boss *c*1 of a friction member *c* slidable on a key *d* on the shaft *e* by means of which, through



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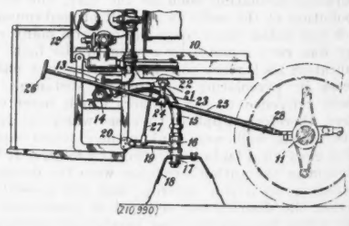
bevel gearing, the hand-operating gear is connected to the bulkhead door. The friction member *c* engages a fixed friction member *f* carried by the adjoining bulkhead. The free end of the lever *a* is acted upon on one side by a spring *g*, the pressure of which is adjustable by a screw *h*, to press the friction member *c* into contact with the member *f* with sufficient force to sustain the weight of the door. On its opposite side the lever *a* is acted upon by a hydraulic ram *i* adapted to overcome the pressure of the spring *g*. The end of the lever *a* is connected by a wire *j* to a remote control, to enable the friction surfaces to be disengaged from the deck by hand operation, and a hand-operated screw *k* adapted to bear against the lever is provided to permit of local disengagement of the friction surfaces. If the hydraulic system should fail with the door in the open position, the spring *g* presses the member *c* into contact with the member *f* and prevents the weight of the door from rotating backward by the shaft *e*. (*Sealed.*)

TEXTILE MACHINERY.

210,990. W. Glossop, Hipperholme, near Halifax. Spraying Apparatus for Treating Road Surfaces. (2 *Figs.*) February 14, 1923.—The invention relates to spraying apparatus for treating road surfaces with tar or bitumen. The invention comprises a spraying device which is supported directly from the chassis and is movable thereon towards and away from the road-surface, the spraying device being connected with a part which maintains a substantially constant height-relationship with the road surface. The chassis 10 is spring-supported on the wheel-axle 11. From the tar-pump 12 a supply pipe 13 extends downwardly and is connected through a swinging junction 14 and flexible hose-pipe 15 with a main nozzle-pipe 16. From the nozzle-pipe extend several jets 17, which are disposed within the customary anti-splash housing 18. The nozzle-pipe 16 is carried by swinging links 19. Each of the links 19 is pivotally mounted in a frame-member 20 extending below the level of the chassis 10. Pivotally mounted on the chassis at 21 is a bell-crank lever, one arm 22 of which is pivotally connected to a link 27 which, in its turn, is connected at its other end to one of the swinging links 19. The other arm 23 of the bell-crank lever is pivotally connected to



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a nut-member 24, and the latter engages a screw-threaded portion of a tie-rod 25. One end of the tie-rod is rotatably mounted in a member 28, which itself is pivotally secured to a fixed part of the casing or bearing of the wheel-axle 11, so that the tie-rod can swing about an axis transversely of the vehicle. The other end of the tie-rod extends rearwardly of the vehicle and terminates in a hand-wheel 26. The tie-rod can rotate in the member 28, but is secured therein so as to be incapable of appreciable relative movement in the direction of the length of the tie-rod. By means of the hand-wheel 26 the tie-rod 25 can be rotated and the bell-crank thereby moved about its pivotal axis to adjust the initial setting of the nozzle-pipe 16 in relation to the road surface. As the chassis rises, for example, in relation to the wheel-axle 11 as the load becomes lessened, the lever-system 22, 23, 27 and 19 will tend to move the nozzle-pipe downwardly away from the chassis proportionately with the movement of the chassis away from the wheel-axle. The converse operation will take place when the chassis is caused to move towards the axle when, for example, the load on the chassis is increased by charging the tar-containers. (*Sealed.*)